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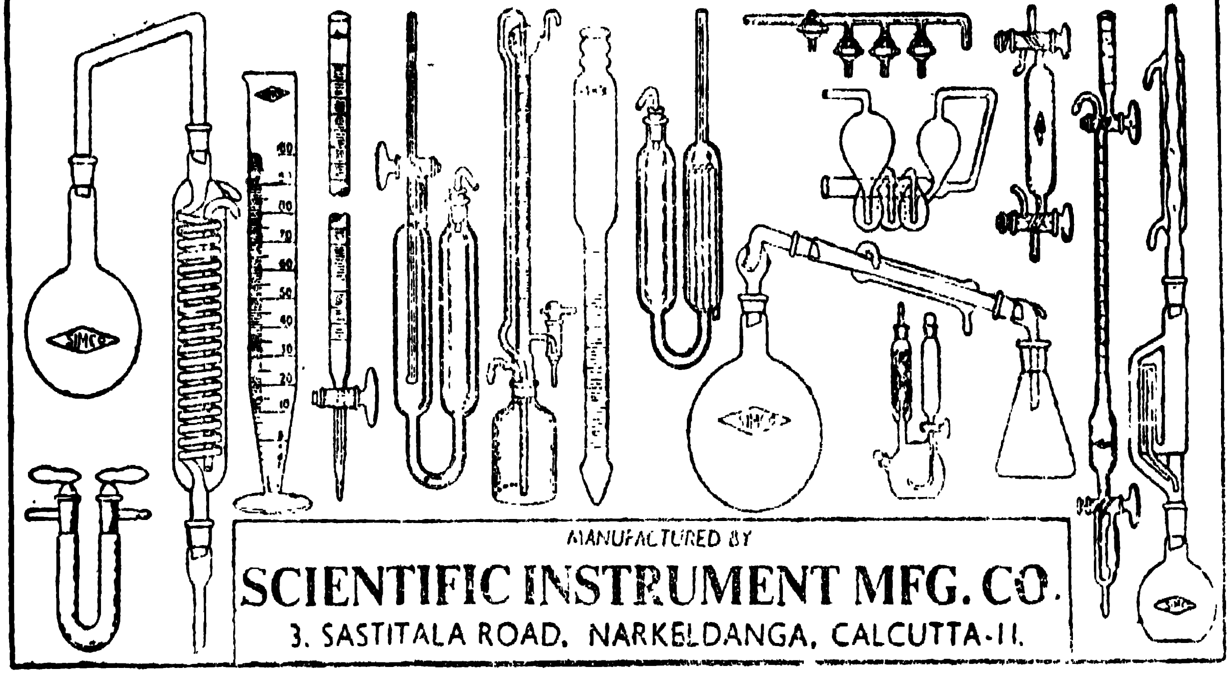

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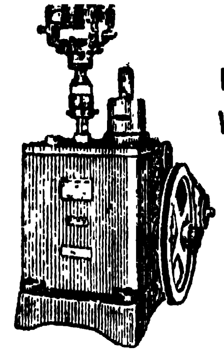

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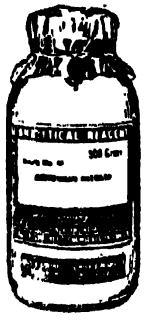

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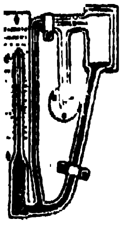

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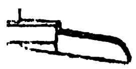

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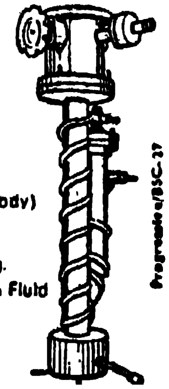

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PERILS OF POLLUTION IN THE METROPOLIS—*S. C. Datta* 177

A New Concept in Plant Disease Control—*A. K. Sinha* 181

Vegetation Cover of India—An Environmental Assessment—*A. B. Chaudhuri* 187

OBITUARY :

T. S. Mahabale—*Sunirmal Chanda* 192

NOTES AND NEWS 194

LETTERS TO THE EDITOR :

Role of potassium cyanide in stomatal physiology of *Clematis gouriana* Roxb.—*Narpat R. Singhvi* and *Keshav D Sharma* 197

On the egg laying behaviour of the apple snail, *Pila globosa*—*S. K. Raut* 198

Effect of a benzyloxy compound on cocoonshell weight following larval treatment in *Corcyra cephalonica* Stainton (Lepidoptera : Galleriidae)—*N. Roychoudhury* and *S. Chakravorty* 199

'Saroda' and 'Sukumari'—new rose cultivars evolved by gamma irradiation—*Subodh Kumar Datta* and *M. N. Gupta* 200

Effect of detergent on the somatic nuclei of *Allium cepa* L.—*Oli Sen* and *Sima Bhattacharya* ... 201

Presence of acidophilic iron and sulphur oxidising micro-organisms in uranium mine sludge of Jaduguda—*D N. Thakur, K. K. Saroj* and *A. Gupta* ... 203

Origin of barite deposits of Vemula area, Pulivendula Taluk, Cuddapah dist., A. P.—*V. Gangadhar* ... 205

Influence of some growth regulators *in vitro* on the pollen growth of *Cicer arietinum*—*Pawan K. Jaiwal* and *S. Bhamble* 207

Screening of some plant extractives for antifungal activity against *Venturia inaequalis*—*D. N. Dhar* and *G. N. Qasba* 209

Studies on a mosaic disease of cowpea from Uttar Pradesh—*B. R. Singh, M. D. Yadav* and *S. M. Dingar* 210

On the phenograms of dominant weeds from West Bengal's industrial belt—*S. C. Datta, H. K. Adhikary* and *S. K. Chatterjee* 211

Effect of liming and manuring on the herbage yield of *Leucaena leucocephala*—*L. K. Prasad* and *S. K. Mukerji* 212

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SCIENCE & CULTURE

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PERILS OF POLLUTION IN THE METROPOLIS

ENVIRONMENTAL pollution in Calcutta and Howrah has assumed a serious proportion in recent years. Alarm bells have been sounded and the metropolis is galloping towards an ecological disaster. The entire stretch of the 140-km^2 area (and also beyond), embracing towns on both banks of the Hooghly from Bansberia in the north to Birlapur in the South, is exposed to ecological perils. Air and water all over the region are being fouled so severely that conditions may soon turn hostile to all sorts of life.

A survey conducted by the National Environmental Engineering Research Institute (NEERI), Nagpur, on the level of air pollution in the two cities reveals frightful findings Every day, about 1 305 tonnes of emissions are released into the atmosphere. Of the total amount of pollutants, about 900 tonnes are generated in Calcutta and the remainder in Howrah. About 44% (560 tonnes) of the pollutants are suspended particles, 34% (450 tonnes) carbon monoxide, 9% (123 tonnes) sulphur dioxide, 8% (102 tonnes) hydrocarbons and 5% (70 tonnes) oxides of nitrogen.

According to the NEERI survey, industries contribute 46% (600 tonnes) of emissions ; this is followed by transportation which accounts for 28% (360 tonnes) and thermal plants 15% (195 tonnes). Suspended particulates constitute the predominant air pollutants, since roughly 370 tonnes of dust are daily deposited on the city. A comparative study of the quality of air in some leading cities of the world indicates that Calcutta has the highest concentration of 527 $\mu g/m^3$ of suspended particles as against 280 in Chicago, 261 in Tokyo, 221 in London and 104 in San Francisco. In India, only Delhi, carries a higher dose of suspended particles in the air than Calcutta, i.e. 700 $\mu g/m^3$. Kanpur and Bombay possess a lesser load of these particles than Calcutta.

A report prepared by the West Bengal Planning Board states that the highest dustfall rate in Calcutta is at Cossipore, where it is 83 tonnes per sq miles a month. The BBD Bag comes next with 77 tonnes, being followed by Manicktala (70 tonnes), Hyde Road (60 tonnes), Tollygunge (55 tonnes), Bhowanipore (49 tonnes) and Sealdah (46 tonnes). However, the dustfall rate is 91 tonnes in Howrah The digging operations of the Metro Railway as well as CMDA and the overflowing garbage lead to the persistently high level of atmospheric dust.

In Calcutta and Howrah, the chief contributors to air pollution are about 2,150 industrial establishments. Bituminous coal, utilised for cooking, and charcoal and firewood, used in bakeries, are held responsible for pollution. It has been estimated that each day 1,200 tonnes of firewood, 730 tonnes of soft coke, 375 tonnes of charcoal and 130 kilolitres of kerosene are consumed by the citizens of Calcutta. Indiscriminate burning of rubber tyres, wood-chips and other items, particularly in winter, pollute the air. Jet planes, mechanised boats and steam engines also add to pollution. There are more than 200,000 registered vehicles in Calcutta and Howrah, but only 6% of the built-up space is available for roads. Consequently, one can notice traffic bottleneck on roads and inefficient operation of vehicles. The unplanned spread of about 5 million people and unchecked growth of furnaces have badly plagued the atmospheric conditions of the twin cities.

As the volume of polluting substances in the air continues to increase menacingly, they deplete the city's volume of oxygen. It is below normal all over the city and its environs, except in the vicinity of the Botanical Gardens at Sibpur, where it is near normal. The Smoke Nuisance Directorate, Govt of West Bengal, has studied the problem and reached the conclusion that the pollution rate is fairly high not only in Calcutta and Howrah, but also in Belur, Bally, Konnagar, Bhadreswar, Chandernagore, Bandel and Barrackpur. The problem is also acute in Kharagpur, Durgapur, Asansol and Raniganj.

Toxic and acidic fumes exist in large quantities in the city's air. Carbon monoxide, which tends to lower haemoglobin in the blood, is distinctly high, although still below the maximum permissible concentration of 40 ppm. In some sections of the city, the proportion of carbon monoxide is slowly and steadily rising to the maximum permissible level. The hydrogen-sulphide content is nearing the permissible limit of 20 ppm at some areas. Sulphur dioxide has crossed the 50 ppm limit in many places. If remedy is not prescribed, experts apprehend that in a decade Calcutta may face a situation similar to the "Great London Fog" of 1952 when London's links with the rest of the world were cut off or "Donora Air Pollution" of 1948 in California (USA) where the death toll went up to 500 within an hour.

Around Birla Planetarium, the concentration of sulphur dioxide is presently 74 ppm, forming an "acidic mist" with the water-content of the air. The earthwork by the Metro Railway aggravates pollution by throwing up clouds of dust. These acid vapours mingle with dust particles, form aerosols and reduce visibility considerably in winter. In that particular spot, the high percentage of fuel (exceeding 5%) and the exhausts from stalled automobiles are augmenting the sulphur-dioxide supply of the air. While the volume of traffic is much higher in the BBD Bag area, they have greater mobility and hence liberate less sulphur dioxide in the atmosphere. The situation is worse than worthless in the Bidhannagar station area, where a series of acid-manufacturing units operate and emit acid vapours all hours of the day. These vapours and dust combine to form a large number of aerosols, affecting visibility adversely. During the past few years, the spurt in train accidents at Bidhannagar station has been primarily attributed to the polluted air.

The problem becomes more acute during winter when frequent atmospheric inversions, coupled with low-wind velocity, envelopes both Calcutta and Howrah, with smog (i.e. thick layers of pollutants of smoky nature and fog), causing irritation of eyes and nose, respiratory ailment and headache. During the monsoon, pollutants are generally dispersed and washed away by rains. Moreover, relatively strong wind blows with an average speed of more than 10 km/hr.

The number of deaths in Calcutta alone from respiratory diseases is greater in the cold-season weather because of heavy concentration of suspended particles admixed with sulphur dioxide. The average number of deaths in December-January is reportedly 400 against 300 in July-August. The bulk of suspended particulates is heavy metals, causing various kinds of cancer. The Bose Institute, Calcutta and NEERI are identifying the particulates to determine which type of metals and compounds cause what type of cancer.

Experts believe that the combination of suspended particles and sulphur dioxide causes extensive damage to vegetation. The yield of vegetables, grown in the proximity of factories and brick kilns, is less than half of that in the non-polluted places. The size of cauliflower and cabbage is reduced, both developing a warhead outlook. Leaves of spinach have big black spots. Even the production of rice crop has been affected.

Environmentalists plead for the planting of more trees in and around Calcutta. A green belt is required to minimise air pollution, improve the landscape and maintain the ecological balance. There should be proper planning and periodic checks on emission of exhausts by fuel-run vehicles. There is general aversion of industrialists to instal reaction-type agglomeration precipitators and other pollution-arresting device. Industries should set up squads to monitor the pollution level in their respective localities. The stacks of new factories should not be less than 40 metres and the boilers must be operated by trained staff to evade belching out of smoke. The consumption of low-grade coal and its substitution by low-temperature carbonised soft coke has been recommended. In every developmental plan of Calcutta and Howrah, the control of air quality should be incorporated.

Like air, water pollution in the Calcutta metropolitan area has attained the critical level. Calcutta's drainage system carries 120 million and 50 million gallons respectively of domestic sewage and industrial waste water. Whereas industries account for 13% of the total wastes dumped into water, 87% of wastes are of domestic origin in Calcutta. In the urban settlements, the khatals, are the big polluters. Large masses of raw cattle waste are washed into the water. The oxygen demand for livestock sewage is several times more than that for untreated domestic sewage.

In the metropolitan area, the Hooghly estuary is getting heavily polluted by the discharge of untreated wastes and there are 346 outfalls dumping waste water from domestic and industrial sources. The Tolly's nullah discharge, including human excreta and carcasse, comprises an immense volume of domestic waste flowing into the Hooghly. Among industrial pollutants, the most objectionable are sodium cyanide and barium salts from heat-treatment furnaces; cadmium, chromium, copper, manganese, nickel and zinc salts from electro-plating units; mobil oil from vehicle-repair workshops. Organic pollutants are high for coke-ovens, distillery, paper and pulp industries, petro-chemical and thermal power plants.

Approximately 1,100 ships call at Calcutta yearly and discharge waste products inside the docks, violating all regulations. Sewage from a larger part of Kidderpore and Garden Reach also finds its way into the Hooghly. As a result, the 5-km stretch between Garden Reach and Bichalighat is one of the worst polluted expanses of the river.

In a survey on pollution in the Ganga river basin, the Central Board of Prevention and Control of Water Pollution has recommended that the lean-season flow (12,000 cusecs daily) should be enhanced substantially. Despite dilution and high-turbulence flow from Farakka, the pollution status of the river has not improved between Palta and Birlapur. Except for an improvement in salinity, the Farakka discharge has had no impact on the quality of water in the Calcutta metropolitan area. The bacterial and chemical content of water is not only much greater than the acceptable level for raw water used by the public-water system, but is also deteriorating rapidly. Water samples from the water-works intake-points at Kamarhati, Serampore, Howrah and Garden Reach have been found to be heavily plagued with faecal contaminants. At these points, bacterial load rises greatly during low as compared to high tides. The density of faecal-based organisms is high, some being resistant to double chlorination. NEERI has cautioned that it makes the Hooghly water entirely unacceptable for conventional treatment processes. This raw water quality is worse than even the fourth grade which the World Health Organisation considers extremely unsuitable for use by public-water supply systems and bathing. It has been strongly recommended that water drawn by all the existing and proposed waterworks should be given pre- and post-chlorination treatment to make the water supplied safe.

Water hyacinth has the capacity to absorb certain metallic pollutants and may be tried by low-cost water-treatment plants. Those municipal towns, having partial or inadequate sewer system, should be encouraged to improve and extend the existing system. Only a few of the towns have proper sewers and even a lesser number has secondary treatment systems. As an economic measure, low-cost stabilisation ponds may be constructed. Most of the urban centres have service privies and the waste collected by municipal agencies are dumped into trenches. As an interim step, all towns devoid of sewer systems should be helped to build sanitary latrines. In view of the lack of road cleaning, the storm water running into sewers appears polluted.

Since the largest element of riverine pollution is disposal of untreated municipal effluents, the ecological significance of sewage-treated fisheries has been pointed out by experts. Such fisheries can be installed between the city and river to reduce the likelihood of contamination of river water. However, harmful chemicals are ingested within the fish and undergo biomagnification. Regular consumption of such contaminated fish would be detrimental to public health. For the same reason, the use of Calcutta's sewage is harmful. Untreated industrial water has to be segregated for domestic sewage before it can be employed for fish farming and raising vegetables.

The sharp deterioration in the chemical quality of the river is borne out by the increase in biochemical oxygen demand and the fall in dissolved oxygen which is making the sustenance of all forms of aquatic life difficult in the Hooghly. The extent of water pollution is reflected in large-scale death among fish, besides the outbreak of epidemics arising out of eating contaminated fish.

The Hooghly estuary once provided excellent spawning beds for some of the most prized fishes like hilsa, mullets, prawns and shrimps. But these species have become rare now-a-days in the estuary, according to a survey carried out by the Central Inland Fisheries Research Institute, Barrackpur. The fish caught in the water between Baranagar and Diamond Harbour yielded the smallest catch, while the lowest part of the river from Diamond Harbour to the Sunderbans produced highest, i.e. about 30 times more than that of the metropolitan component. The catch consisted of more than 120 species. Year-round discharge of industrial and domestic wastes, coupled with a low level of water, has significantly altered the ecosystem of the river and the trend of fish yields from it.

Apart from the Hooghly, groundwater in vast tracts of Calcutta and Howrah has become affected due to unscientific disposal of garbage in marshy lands and swamps. About 2,000 tonnes of Calcutta's garbage is dumped daily at Bantala and Dhapa for land-filling operations. Environmentalists suspect that groundwater resources of a large portion of east Calcutta have been spoiled due to this. It is a small wonder that the incidence of water-borne diseases in east Calcutta is higher than in the other areas of the city. Since water stagnancy on farm lands for transplantation may enhance the pollution of shallow-level ground water through increased percolation of dissolved farm chemicals and coliform organisms, a few deeper tubewells may be sunk in the adjacent villages. The application of toxic organochlorine pesticides may be discontinued to check water pollution.

In order to get rid of the stinking garbage, Calcutta can perhaps emulate the example of Singapore which is apparently a model for sound environmental management. Over 50% of the refuse is incinerated, since the land available for dumping is scarce in the small island republic (26 miles by 14 miles).

The heat generated by incineration is harnessed to produce 11 MW of electricity, out of which 3 MW is used for running the plant whose gross operation cost is S $ 19 per tonne. The remaining power is supplied to the national power grid which is enough to lit all the street lights of Singapore. Refuse incineration indeed seems attractive for tackling the grim power crisis being faced by the Calcutta metropolitan area.

The ever-growing megapolis is not immune to the evils of noise pollution. The towns are more noisier than the outlying villages. Calcutta, alongside Delhi and Bombay, are thought to be among the noisiest cities in the world, where the average noise level was 90 dB in 1970. Traffic-noise measurements conducted by the Bose Institute, very recently (February, 1984) at different traffic points of the city show that the average sound level is 75 dB which is beyond the acceptable limit. During periodic bouts of load-shedding, whirring of generators and blaring of transistors add to the din. The shrill horns of mini-buses, lorries and taxis shatter the relative tranquility of the hospital areas and shock the migratory birds into silence. While nearly 20-40 dB are assumed to be normal, 120 dB lead to pollution hazards, such as loss of hearing, increasing heart beats, emotional distress, blood pressure and sleeping sickness. Some of the remedial measures include the protection of hearing via cotton plugs and working in insulated chambers. The programme for conservation of hearing is one of the most essential requisites for a tension-free life amidst the noise boom.

Specialists confirm that, in respect of environmental pollution, Calcutta ranks rather unfavourably with other principal cities of the globe. It not only can be a health hazard, but can cause damage to property and vegetation. Signs of an approaching disaster have been in evidence for more than a decade, but only half hearted measures have been adopted to combat the nuisance of pollution. It is however, a happy sign that environmental considerations have figured prominently in West Bengal Government's plans and programmes for the city and the concerned authorities seem to be aware of the need to conserve the precious environment in which Calcuttans live, move and have their being. ☐

S. C. Datta

A NEW CONCEPT IN PLANT DISEASE CONTROL

A. K. SINHA*

CONCERTED efforts are being made all the world over for maximization of food production. Plant disease control, aimed at better crop production and greater yield, provides one of the major approaches to achieve that objective. A good control measure should be such as to effectively reduce disease to an acceptable level, be economically sound and not pose any hazards, but this is not always achieved. Intensive cropping practiced these days with the use of adequate fertilizer and other inputs to draw the maximum out of the land has led to an increase in the incidence and severity of many of the major crop diseases and to the origin of many new races of the pathogen. This has complicated the disease situation further and makes the need for good control measures more obvious.

Use of a resistant variety, no doubt, provides the most effective as well as the cheapest method of plant disease control.

---

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However, the production of a new variety, which incorporates both the character of resistance as well as good agronomic qualities, is a time-consuming process. Further more, chances are that sooner or later such a variety will fall prey to a new virulent race of the pathogen and suffer great damage. So, in most cases of disease outbreak in severe form there is little alternative left but to resort to chemical control by the use of such toxic substances as fungicides, antibiotics, etc. Continued and excessive use of fungicides may create many problems such as their residual effects on human population, environmental pollution with attendant harmful effects on other organisms and chances of the pathogen developing resistance to the chemical in time. Because of such dangers and disadvantages inherent in the regular use of toxic plant protection chemicals, considerable emphasis is being placed these days on cultural practices including crop sanitation with the aim of alleviating disease by manipulating plant environment so as to keep inoculum level within a limit. Though few diseases can be completely controlled by the use of such methods alone, these are undoubtedly valuable as subsidiary aids.

In a situation as described above, faced with dangers consequent upon the excessive use of toxic plant protection chemicals, there is a growing feeling, particularly among the plant pathologists, that fresh avenues must be explored and some alternative methods developed that will be safer and less hazardous than the use of such toxic chemicals. Plant disease control through a strengthening of host's own defence by treatment with nontoxic or less toxic compounds may offer such a possibility. There are substances which, although not toxic to the pathogen in vitro, may exert a protectivs effect against it when applied to the plant. Some of the systemic compounds belong to this category. The scope of this concept in plant disease control is being discussed here.

Idea of treating plants with chemicals for disease amelioration dates back to many centuries. Initially, only toxic compounds like copper and mercury salts were used. Later in the twentieth century, particularly after the second world war, many fungicides had been developed which provided plants with effective protection against many of their major diseases. Besides, in more recent years, many compounds of widely divergent nature and with little or no direct toxic action have also been tried against many plant diseases and significant levels of success has been achieved with some of them.

Among the heavy metal salts, those of copper, which are of fungitoxic nature, have been used most, but in some such cases the nature of treatment and the concentration used precluded any direct toxic action as the possible cause behind the reduction of symptoms. Application of copper salts developed systemic anti-mildew activity in cereals[25]. Seed treatment with copper sulphate and boric acid reduced brown spot symptoms in rice seedlings[4]. Lithium salts effectively controlled both rust[18] and powdery mildew[35] infection of cereals. Application of sodium borate solution to the roots reduced both brown and yellow rusts of wheat under field conditions[13] and also linseed rust[14]. Boric acid, copper sulphate and zinc sulphate were effective in seed treatment against leaf rusts of wheat[27]. Treatment with zinc chloride checked fire blight of pears[23]. Root application or seed treatment with manganese sulphate gave effective control of *Fusarium* wilt of pigeon pea, complete control being achieved with 100-200 ppm[36]. Even other salts have been used occasionally with good effect. Foliar spray with magnesium salt checked bean rust infection[19]. Many wheat varieties suffered less damage when potassium or sodium chloride was added to the soil[28]. Soil drench around the stem base with calcium salts have often helped to check *Rhizoctonia* infection and *Fusarium* or *Verticillium* wilt in different plants.

Effectiveness of some amino acids in controlling plant infection has been reported[39]. There are reports of increased host resistance in apple to scab disease with DL-phenylalanine and in cucumber to *Cladosporium cucumerinum* with DL-serine, DL-threonine and some other amino acids[38]. DL-serine was also effective on broad bean against *Botrytis fabae* and on potato tuber and tomato leaves against *Phytophthora* sp. Pea plants became resistant to *Aphanomyces* root rot when treated with some sulphur containing and sulphur lacking amino acids[26]. Similar reports are available for apple against powdery mildew with DL-methionine[8], rice against brown spot disease with L-methionine[29] and tomato against *Fusarium* wilt with DL phenylalanine[6]. Generally, DL forms of amino acids are more active in inducing resistance in plants than their L-forms

Plant growth regulators have been used with good effect mostly against different vascular wilt diseases. Significant reductions in *Fusarium* wilt symptoms in tomato were achieved by treatment with indole-3-acetic acid (IAA), 2, 4-dichlorophenoxyacetic acid (2, 4-D), napthalene acetic acid (NAA) and 2, 3, 5-tri-iodobenzoic acid (TIBA). On the same plant, striking reductions in *Verticillium* wilt symptoms were recorded with napthalene acetamide and cycocel, a growth retardant[32, 33]. Dutch elm disease has been effectively checked by host injection with 2, 3, 6-trichlorophenoxyacetic acid (2, 3, 6-T)[34] and some other growth regulating substances[3]. There are a few reports of success against other kinds of disease also such as chocolate spot of bean with β-napthoxyacetic acid[5] and wheat stem rust with sodium propionate and cucumber scab with some growth retardants[10]. Tobacco plants acquired systemic resistance to TMV when treated with cytokinin[2].

Besides the above groups of chemical, many other compounds have often been tried for disease control and success occasionally reported. Foliar spray of 8 day-old wheat plants with several sulphonamide compounds inhibited rust development throughout[24]. Established rust infection in wheat was checked by treatments with saccharin and picric acid[16] and various phenylhydrazones[17]. Seed treatment with hydroquinone and polycin solutions prevented any severe infection with *Cochliobolus sativus* and *Gaumannomyces graminis*[30]. Rice plants raised from seeds wet treated with dodecyl-DL-alanine hydrochloride developed considerable resistance to *Piricularia oryzae*[1] ; the induced effect became maximum after 30 days and continued at that level for 75 days. Soil application of catechol through irrigation water completely protected tomato and brinjal plants against *Fusarium* wilt[7]. Similar protection for tomato plants was also achieved with quinic acid, a precursor of polyphenols[9]. Soil drench with Carolate, a mixrure of lime, urea, salicylic acid and an azo dye, was quite often recommended at a stage for the control of dutch elm disease[22].

It must be apparent from the above that a wide array of chemicals other than toxic fungicides, antibiotics, etc. can provide considerable protection to different plant species against some of their pathogens. In most such cases, nothing is clearly known about their probable mode of action except that these must have altered host metabolism in such a way as to make the spread or continued activity of the pathogen in the host tissue difficult. Only in a few cases, there was some suggestive evidence for a possible mechanism, rarely any positive proof. After absorption into the host tissue, some of these compounds are possibly converted into toxic derivatives, induce the production of some toxic substance by the host or antidote the toxin produced by the pathogen. Others perhaps change the cell wall or tissue structure in a way that make the continuance of infection difficult. Quinic-acid treatment causes accumulation of its toxic phenolic derivatives in tomato plants and provides protection against *Fusarium* wilt[6]. Protection resulting from amino-acid treatment appear to be correlated with the accumulation of toxic phenols like phloridzin, phloretin, etc. in apple[15] and some new fungitoxic phenols in cucumber[38]. Growth regulator induced resistance against vascular wilt pathogens has been mostly found to be well correlated with growth inhibition[8, 9, 32-34]. It has been suggested that growth regulators provided protection by modifying pectic substances in the host cell wall so as to make them resistant to pectic enzyme action and also inhibit growth along the vertical axis. Elm plants treated with 2, 3, 6-T and showing resistance had shorter and narrower spring wood vessels that do not permit any rapid colonization[34]. Effectiveness of calcium salts in checking ***Rhizoctonia***, ***Fusarium*** or ***Verticillium*** infection also seems to be based on their ability to alter cell wall pectic substances. Resistance induced in tomato plants to ***Fusarium*** wilt by treatment with catechol appears to be linked with suppression of toxin production by the pathogen[7]. Rice seedlings spray treated with L-methionine not only developed many fewer and smaller lesions as compared to the untreated plants but these lesions also had fewer spores[29]. Such antisporulant action of L-methionine may keep the inoculum build up in check.

It has to be admitted that in most of the cases referred to above the test chemicals had been used without any definite idea as to how they would act. In that context, studies at Bidhan Chandra Krishi Viswavidyalaya mark a distinctly fresh approach[13, 31-33, 37]. In a series of experiments, a large and diverse group of chemicals have been tested for their possible protective effect on rice plants against the brown spot pathogen, ***Helminthosporium oryzae***. These include heavy-metal salts, amino acids, reducing agents, metabolic inhibitors, plant growth regulators, etc., all known for their ability to induce the production of phytoalexin-type resistance factor in plants. Such compounds were used in the expectation that they would induce the production of phytoalexin-type antifungal substance in rice plants to levels high enough to provide them protection from *H. oryzae*. Initial studies involved foliage spray with dilute (10^{-3} to 10^{-5}M), mostly non-toxic concentrations of some of these compounds 2 days before challenge inoculation. Brown spot symptoms were very significantly reduced in many of the treatments : there were reductions both in the number and size of lesions[30, 37]. More effective ones were used for both root-dip or wet seed treatment by soaking for 24 h. Treated seedlings displayed appreciable protection against brown spot disease in most of the treatments, the induced effect gradually declining with time. In terms of the level of resistance induced and its persistence, seed soaking appeared to provide the most effective form of treatment with these chemicals. In some cases of seed treatment, the induced protective effect persisted at significant levels even up to 5 weeks in both laboratory and field trials[13]. Among the chemicals tested, ferric chloride, cadmium chloride, Dl-methionine, sodium malonate, sodium molybdate and IAA showed greater promise than others. Detailed studies with five other highly potent phytoalexin inducers, used in wet seed treatment, led to observations of great scientific interest. These compounds provided high level protection to rice seedlings up to 4 weeks, but with sodium selenite and thioglycollic acid appreciable effect persisted even up to 8 weeks[31]. Considerable fungitoxicity initially developed in treated seedlings disappeared in 3-4 weeks time. However, the same plants developed considerable to marked fungitoxicity when inoculated at 4-week-stage as compared to only mild toxicity developed in comparable untreated plants. Only with sodium selenite and thioglycollic acid, such increased post-infectional production of fungitoxic substance continued beyond 4 weeks and up to 8 weeks though with declining efficiency. Good correlation existed between the level of protection provided to rice seedlings in different treatments and the fungitoxicity post-infectionally developed in them but not that initially induced. Such facts indicate a conditioning effect of seed treatment on emergent seedlings. It has been concluded that conditioned and sensitized susceptible rice seedling tissue responds to infection like resistant tissue, produces phytoalexin-type resistance factor in such higher amounts than is usual and thus gets protected from the pathogen[3 1]. Biochemical and serological studies have provided further evidence of tissue conditioning. It has been found that rice plants raised from seeds treated with sodium selenite and cysteine showed initial changes in protein content and peroxidase activity to levels nearer those in resistant plants and that their responses to infection in respects of phenol, protein and total sugar levels and polyphenoloxidase and peroxidase activities were more like those of resistant than those of untreated susceptible plants. Such changes were clearly evident up to 4 weeks in both treatments but with sodium selenite, which provided good protection up to 6 weeks, also continued up to that stage. Serological studies based on immuno- and gel electrophoresis also provide very significant information. It was found that three common proteins (antigens) shared by susceptible plants with the pathogen, which were not present in resistant plants, were also absent from treated susceptible plants. Moreover, as a result of treatment, there appeared in susceptible plants a new protein corresponding to one present in resistant plants. This is for the first time that exhaustive evidence has been presented for tissue conditioning as a possible factor in chemical induction of disease resistance in plants. Such conditioning towards an altered state of dynamic defence make treated susceptible rice plants behave like resistant plants when confronted with the pathogen. This property of certain chemicals need to be further explored and utilized for plant disease control. The ability of rice plants to be conditioned, in response to chemical treatment, with much heightened dynamic defence potential is not restricted to any particular cultivar. Other plants, both monocotyleconous and dicotyledonous, may also similarly respond. More than twenty phytoalexin inducers have been screened for their effectiveness in seed treatment in controlling leaf spot infection of wheat incited by *Helminthosporium sativum*. Many of them caused very significant reductions in symptoms even up to 5 weeks. But in the case of wheat, induced conditioning effect appeared to be less pronounced. There was also a difference in the relative effectiveness of different chemicals on rice and wheat plants. Initial studies on the stem rot of ground nut incited by *Sclerotium rolfsii* and *Fusarium* wilt of pigeon pea have also indicated promise. It is concluded, therefore, that the development of resistance to potential pathogens following treatment with chemicals may be a general kind of response widely shared by many plant species, but for each plant and may be for its different host-parasite combinations, separate explorations would be necessary to locate the most effective chemicals. The induced protective effect is not permanent and gradually weakens but remains operative at fairly high level up to 4-5 weeks in many instances. This kind of treatment will have greater chance of success in the case of plants suffering heavily from infection at early growth stages, particularly from compound interest diseases where reduced number of lesions with smaller size may make the required quick build up of secondary inoculum really difficult. Where the vulnerable stage of the host continues beyond 4-5 weeks or occurs little later, a second treatment at that stage in the form of foliage spray may help to prolong the induced protective effect for a few more weeks. All these possibilities, however, need to be investigated.

Advantages of phytoalexin inducers over the traditional plant protection chemicals lie in the fact that they act *in vivo*, after absorption into the host tissue, to create there against a possible attack from the pathogen a static defence initially and also a dynamic defence potential which will continue to operate for some time. Many other chemicals, which are not yet known as phytoalexin inducer, may also share this property.

The essence of this approach lies in artificially bringing into operation as well as keeping in readiness in anticipation of a possible attack some of the normal sequences of responses that characterize the natural defence of the host plant. It may actually mean an activation, under the influence of chemical treatment, of the natural dynamic defence potential that somehow remains suppressed in the case of a compatible host-pathogen interaction. This will, therefore, be nearer to and more in tune with plant's own system of defence than any other form of chemical defence so far practised. In the context of such advantages and hazardous consequences of the continued and excessive use of fungicide type toxic compounds, the possibility of plant disease control by the use of phytoalexin inducers and other less toxic or non-toxic chemicals merits intensive exploration. □

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VEGETATION COVER OF INDIA —AN ENVIRONMENTAL ASSESSMENT

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Thus spake the tree "I am the gift
of God and friend of man".

IT is trees that make this world livable. Sans trees, the world will die of barrenness. Trees are also our natural landmarks and memorials. Trees are part of our amazing heritage. Trees have contributed immeasurably to the economic growth, political climate and spiritual ethos of our nation. The beneficial roles of forests (community of trees) have been stressed in our scriptures and the civilisation of our country have centered around the forests. So aptly the Indian civilisation is called the forest civilisation. Our Prime Minister has also lately underlined the role of forests in maintaining the ecological balance and national development. She has repeatedly stressed the need for conservation of forests and wildlife While launching the world conservation strategy, she said "The manner in which we are encroaching upon our forests and mountains and are permitting the indiscriminate cutting of beautiful and useful old trees is alarming. Inspite of the Government of India's policy resolution we have lost large forests in last 30 years. As a result there have been soil erosion, floods and the silting of reservoirs, canals and rivers. Large tracts of land have become saline and alkaline One of our immediate tasks", she pointed out, "is to restore the ecosystem of the Himalayas and other mountain ranges". "Can we ensure" she asked, "that by the end of the century the Himalayas will have the same extent of vegetation cover as prevailed in the beginning of the century ?"

Forest Ecosystem

The forest ecosystem is a vital part of the natural resource system because of its multiple role in influencing the environment and moderating the climate, maintaining soil cover, regulating water and purifying the air. Forests tend to trap the solar energy by photosynthesis—a critical energy-storing process on earth on which life processes of almost all organisms depends. Forests have a significant role in keeping up the productivity of land on which our agriculture depends to a large and significant extent.

Depletion of Forests

But the extent and quality of effective cover have suffered a lot during the foreign occupation of the country for about ten centuries. Extensive areas supporting natural tree growth came under reckless exploitation. Destruction of forests for various purposes has led to intense environmental degradation. This situation has been complicated further by fantastically high human population (700 million) and grazing animal (330 million) growths The forests areas of the country have shrunk under pressure of rapid industrialisation. The meagre area under forest cover is dwindling rapidly. About 5 million hectares have been deforested The bulk area of the country in arid and semi-arid zones is undergoing erosion. Humid and semi humid areas are suffering from water erosion. The ravines have eaten up more than 7 million hectares of land. More than 48 million hectares of land have been cleared for river-valley projects. Damage caused by erosion to soil fertility is estimated at 3,7000,00 tonnes per year. The aforesaid figures provide, to be frank, conservative estimates of what really the situation is. A low air flight all over the country will testify to the dismal land-use pattern and to the unsatisfactory nature of scanty vegetation cover and growing erosion. Frequent floods due to loss of forest cover take a heavy toll of property and human lives every year; this has been computed to be of the order of 2400 crores of rupees annually. Siltations have threatened the Bhakra, Hirakud and Nizamsager reservoirs. Siltation losses have been computed to be Rs. 5000/- crores and the loss due to denudation of cover has been quantified to be Rs. 30,000/- crores during the last 20 25 years. Nearly 30 million hectares of tropical forest land are found to be fragile. But clear felling is still being done to raise pure crops. Laterite soil is infertile. Barren and unproductive land in the country amounts to 38.3 million hectares.

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Forests in Doldrums

The conservationists in India think that Indian forest management policy is in doldrums. Foresters could not envision the tremendous pressures our vast ever-growing population would exert on the forests for fuelwoed, fibre, timber and other forest produce. Our forest policy for long continued to be hide-bound and was not modified to suit the changing socio-economic conditions of the people. No scientific and administrative measures were taken to meet the needs and change of changed circumstances in forestry. The foundation of forestry management policy suffered a severe set back from the relentless hecking of forests for fuelwood, fodder, timber etc. A very limited supply of gas, electricity, kerosene and other such facilities compelled the majority of people living in the country-side to depend more on forest produce. Even the educated intelligentia failed to realise that the renewable natural resources could be rendered useless if no viable policy is adopted to conserve and replenish forest resources.

The aforesaid situation has resulted in uneven spatial dispersion of forests. Vast areas of the Indo-gangetic plains, coastal strips and other fertile valleys were either devoid of forests or they carry only resudial forest crops. Dynamics of industrial development have also given rise to a host of environmental problems. Again, large areas of forests are situated in inaccessible mountain ranges away from habitation. It is well to mention here that the village economy in the hills is based on having vast number of cattle wealth. The villagers grazing rights and rights to collect forest produce were acknowledged. Many tracts of north-eastern, south-central and central India were depleted under the pressure of shifting cultivation (more than 1,40,000 sq km). Large forest areas under control of the revenue department, private individuals and corporate bodies suffered intense depletion. Reserved and protected forests were encroached upon and in many cases such encroachers were resettled in forest lands. Grazing and fire stripped off vast areas of vegetation cover or diluted it. Lopping and collection of fodder also reduced cover density.

Cover Statistics

Several national and international organisations have challenged the statistical figures on vegetation cover put forward by the Department of Forests and on the exact nature of its density. The much-bloated claim that India has 22.8% of geographical area under forests is far from true when evaluated in terms of cover and density. The cover area (22.8%) includes banks, riverbeds snowcapped mountains, grasslands and pastures; it also includes open forests of shrubs, shrub savvanahs, scrub savvanahs, scattered tree-covered areas with no undergrowth, tree-covered areas with no middle canopied forest or ground cover. The forests of these types have little value for soil and water conservation, and climatic amelioration. The international conservation organisations feel that India does not have more than 10% of geographical area under tree cover. In his convocation address delivered in F. R. I. and colleges, Dehra Dun in June 30, 1982, T. N. Khoshoo said, "And today, in India, effective cover is hardly 12%

as against 33% envisaged under National Forest Policy. Equally important are the factors like grazing by livestock, lopping of trees, forest fire, introduction of exotics and consequent replacement of indigenous species of plants and animals, excessive use of synthetic pesticides and fungicides and unabated international demands for some of the indigenous species, such as skins of different animals, orchids, rhododendrons etc."

Unfortunately, the Department of Forests does not have any authentic statistics to challenge the contentions of national or international bodies on vegetation cover. One must clearly know what the actual situation is. Otherwise, the planners, conservationists and administrators will be unable to take correct decision about various developmental works.

Aerial Photo and Satellite Imagery Interpretation

A reliable picture of vegetation cover and their density can be had from interpretation of aerial photographs of 1 : 6000, 1 : 10,000 or 1 : 15,000 scales. A rough and acceptable figures can be had from aerial photographs of a 1 : 25,000 scale. But in India aerial photographs of the scale 1 : 50,000 is only available for the entire country. In this respect, remote-sensing satellite imageries can hardly serve our purpose as they are on a scale of 1 : 1 million ; these imageries can serve only a macro-level estimation of cover and cannot delineate much detail of the density of cover. Unfortunately the competent organisations like Survey of India and National Remote Sensing Agency (N.R.S.A., Dept. of Space) have not done, as of now, much micro-level work in estimating vegetation cover.

In November 1982, the Prime Minister of India expressed her concern about the absence of reliable data on vegetation cover of the country. The Forest Survey of India (F. S. I.) undertook the work of preparing a macro-level vegetation cover map from Band 5 Black & White imageries received from NRSA. A report with maps was prepared describing the types of cover. But this work was not given wide publicity, possibly because of the imageries having had some inherent defects jeopardising correct assessment of areas.

Unrealistic Legends

The legends which were used by the erstwhile Preinvestment Survey of Forest Resources and later by Forest Survey of India hardly answered all details of vegetation cover and density concerning environmental amelioration. Owing to the pressing necessity of ascertaining some macro-level information on vegetation cover, old legends were adopted. These were : (i) Closed vegetation cover (cover closure of about 40%), (ii) Open vegetation (cover closure of 10-40%), (iii) Closed vegetation affected by shifting cultivation, (iv) Open vegetation affected by shifting cultivation, (v) Water bodies, (vi) Cloud cover, (vii) Other land use types. The study of maps prepared from the aforesaid imageries revealed that (a) 11.25% of the geographical area of the country is under closed cover, (b) 9.25% of the geographical area of the country is under open and degraded cover.

Actual Need

For a quick and realistic assessment of vegetal cover and land use types (macro-level), it is necessary to examine Black and White imageries of Bands 5 & 7 or false colour composites of Bands 4, 5 & 7 and enhanced or corrected landsat products. An interpretation of such products will also provide a macro-level picture of vegetal cover and other land use types.

For assessment of vegetal cover in north-east India, the Forest Survey of India (FSI) made visual interpretation of landsat imageries of Bands 5 & 7, Black & White and false colour composites on Bands 4, 5 & 7 for the years 1975-76, and imageries on Band 5 (Black & White) of the years 1980-82. The legends of interpretation remained

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as above. The findings from the analysis of data revealed that shifting cultivation has depleted vast areas of vegetation. Moreover, the recession of forests over the period of five years may be seen from Table 1.

TABLE I

Land-sat imagery II - Imagery of 1975-76

State	Closed forest (Sq km)	Degraded forest (Sq km)	Closed forests with shifting cultivation (Sq km)	Open forest with shifting cultivation (Sq km)
Assam	19411	5987	2504	1652
Manipur	2771	—	13292	4476
Meghalaya	4353	1601	5233	5008
Nagaland	4494	283	2444	8531
Tripura	2855	170	4378	1838
Mesoram	4188	12	13521	2592
Arunachal Pradesh	57024	468	3315	4629
Total	95096	8521	44687	27736
Land-sat imagery in band 5 Black & White 1980-82				
Assam	18150	4060	3300	3160
Manipur	3480	50	12660	2400
Meghalaya	4560	900	4710	3800
Nagaland	5260	210	2610	6270
Tripura	1450	160	4450	960
Mesorum	530	—	17290	1150
Arunachal Pradesh	30880	540	10700	1580
Total	65310	5920	55700	19320

The aforesaid figures reveal that between 1975-76 and 1980-82 an area of 8054 sq km of area has been denuded of vegetation. An area of 3642 sq km of close forest has been made degraded (Arunachal excluded).

Realistic Definition of Vegetation Cover

Prior to quantifying vegetation cover, the parameters should be defined in clear terms. Evaluation of the types of cover has to be done on the quality of such definitions; otherwise, more saying that India has 12% of its area under effective vegetation cover (often quoted by conservationists) does not provide any useful clue. For instance, trees standing scattered in paddy fields or elsewhere do not contribute to the vegetation cover area of the country though such trees ameliorate climatic conditions to some extent. Even small groups of trees in homestead land, in orchards, scattered shrub forests, shrub or scrub savannahs, open grasslands do not effectively contribute to atmospheric amelioration and must not strictly be counted under effective vegetation cover. Yet a fullproof definition and exact picture of cover can be had, keeping in view the following facts :

(i) Trees having dense crown cover (100%) may not even be effective against erosion in a very heavy rainfal area without under-storey or ground vegetation.

(ii) Again, trees having 40-60% crown cover, but without under-storey vegetation may not form effective cover against erosion and offer atmospheric amelioration.

(iii) The bulk forests of the country in dry tracts compromising dry deciduous forests and thorn forests (45.6% of total forests) do not have either second storey vegetation or ground cover.

(iv) Also, evergreen, semi-evergreen and moist deciduous forests (39.4% of total forests) do not have effective ground cover all over.

Basic Work Undertaken

In 1981, this author prepared a report (with maps of the country) indicating forests which were still retaining good forest cover. He identified 10,000 sq km areas as having such cover. Other work that followed on this subject include : (i) Draft report on the mapping of vegetation cover of India (Landsat images of Band 5 Black & White of 1980-82), (ii) Vegetation classification and mapping for assessment of forest resources in India, (iii) Interim reports with maps (based on interpretation of satellite imageries and aerial photographs) on the Himalayan Forests, (iv) An atlas of Forest types of India. Their findings, (as yet under old legends), revealed that India has 11.75% of the Forest area under closed vegetation cover, and 9.25% under open vegetation cover.

About the Himalayas, the following had been the findings : (figures represent the geographical area of each of the state) :

State	Good forest cover	Degraded forest cover
Jammu & Kashmir	6.4%	5.5%
Himachal Pradesh	10.1%	29.2%
Arunachal Pradesh	68 2% (Good, medium and open forests)	
Nepal (western)	15.8%	17.3%
Bhutan	53.7%	17.8%

Considering all these facts, one should find that assessment on vegetation cover is a complicated subject which calls for (i) examination of top quality imageries, (ii) proper expertise to interpret them and (iii) dependable botanical and ecological knowledge.

The Department of Environment realised the importance of the subject and constituted a high-level committee involving Forest Survey of India, Survey of India, National Remote Sensing Agency and National Atlas and Themetic Mapping Organisation. The work has been in progress since early 1983.

On the basis of the research work, this author has done through work and has arrived at some reliable figures which are detailed in Table 2. It is hoped that they will be of some help to future researchers on the subject.

TABLE 2

State	Closed forest (Sq km)	Open forest (Sq km)	Denuded forest (Sq km)
Bihar	9986	10000	5150
Gujarat	4658	7000	3842
Himachal Pradesh	4030	6000	5646
Jammu & Kashmir	8421	10000	7114
Karnataka	14643	17000	12599
Kerala	5990	6000	3614
Punjab	1140	1400	1728
Rajasthan	6068	16000	9118
Tamil Nadu	7621	8000	7016
Uttar Pradesh	11722	20000	14835
Goa, Daman & Diu	670	900	435
West Bengal	5000	2000	2317
Sikkim	2200	400	408
Andhra Pradesh	15784	22559	18714
Madhya Pradesh	29960	44160	25495
Maharastra	10982	18611	11421
Orissa	13960	13368	24944
Andaman	6000		
Total	158715	203398	* 154396

Combining the figure presented in Tables 1 and 2, vegetation cover has been assessed as follows (figures in sq km) :

Table	Closed Forests	Open Forests	Degraded Forests
1	65310	55700	25240
2	158715	203398	154396
Total	224025	259098	179636

The following conclusions may be arrived at from the analysis of the aforesaid figures :

(i) 20.2% of the geographical area of the country has some type of cover. (This must not give any idea of effective vegetation cover of the country from the climatic or environmental amelioration point of view.)

(ii) 33.3% of the existing cover as in (i) (or 6.8% of geographical areas) has good forest cover.

(iii) 13.4% of geographical area has forests which are open or degraded.

The observations made in this paper are based on reliable aerial photographs and satellite imageries; the maps have been checked and rechecked in the fields. It is believed that this paper makes available for the first time the most authentic data on vegetation cover using most up-to-date research tools. It is expected that the planners and administrators will make fruitful use of these data in planning and executing future plan projects. ☐

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OBITUARY

T. S. MAHABALE

It was on 19th October 1909 a child was born in Ahmednagar in the Mahabale family who was given the name Tryambak Shankar, a name which later became well known in the realm of Indian scientific community and abroad pertaining to Natural Sciences, Botany in particular. Young Mahabale had his early education in Ahmednagar and Nasik, later he graduated from the Fergusson College, Poona in Science in 1932, subsequently in Arts in 1934. Already at that stage one could notice his great love for nature as a keen observer and an ardent collector of plants. In this act of his observation of the nature he succeeded in discovering subterranean prothalli in some *Ophioglossum* from the vicinity of his College, worked on them and submitted a thesis for M.Sc. degree to the Bombay University in 1935 under the guidance of Prof. D. L. Dixit, which later formed a part of his Ph.D. thesis. The Bombay University awarded him the Ph.D. degree in 1939, which, incidentally was the first Ph.D. degree in Botany from the Bombay University. Thus he was one of those who started a research tradition in Botany in that University.

T. S. Mahabale

After a few changes in his early service career he joined the Fergusson College, Poona, as a Lecturer, and later served the Bombay Government as a Lecturer in Gujarat College, Ahmedabad and as Associate Professor at the Institute of Science, Bombay. He worked for "Wealth of India" during 1945-46 as an Assistant Editor. He joined the University of Poona in 1953 as Professor and Head of the Department of Botany. The Botany Department gained a fame for excellence in research and teaching under his successful leadership.

Mahabale published well over 140 research papers and a monograph on palms. The publications show a testimony of his wide interest in various plant groups ranging from Bryophytes, Pteridophytes, Angiosperms to Palaeobotany. He received early training from Prof. D. L. Dixit of Poona and Prof. M. A. Sampathkumaran of Bangalore in Cytology and Pteridology. Later it was Prof. Birbal Sahni who created a great interest in him in the studies of fossil botany. He was given a task to work on the Tertiary flora of Deccan because of his thorough knowledge in the living plants of that area. Fossil flora of the Deccan Intertrappean Series infused a great interest in Mahabale for the uniqueness, richness and wonderful preservation. He created an active school of palaeobotanists who fruitfully contributed to the studies of fossil plants from Palaeozoic to Pleistocene.

The last phase of Mahabale's research career kept him busy mainly with palms, fossil and living. A large number of fossil palms were recovered from the Deccan Intertrappean Series and were described under an artificial genus *Palmoxylon.* He felt that a thorough study of living palms was necessary to resolve the vast artificial fossil genus *Palmoxylon.* In this context he devoted the last five years of his life to synthesize the vast data morphologically and anatomically which he and his collaborators collected for several decades. With the years, this subject became an exclusive speciality of his school. Specimen collections were made nationally and internationally, from Andamans, Srilanka, Aden, Italy and other places. Even when his health was failing in the last years, the urge to know took him to Indonesia and Singapore to study the palms growing in these countries. He visited various herbaria and gardens in Europe, U.S.A. and U.S.S.R., spent a good amount of, time to study Webb's and Beccari's original collection of palms at the University of Florence, Italy.

Many responsible and honourable offices were held by Mahabale during his life time in various capacities. He served the Indian Botanical Society as Secretary from 1947-49, as Vice-President in 1950 and as President in 1968. He was elected Fellows of the National Academy of Sciences, Allahabad; Indian Academy of Sciences, Bangalore and Indian National Science Academy, New Delhi. He was also a Foundation Fellow of the Maharashtra Academy of Science. He got elected as President, Botany Section of the Indian Science Congress in 1966 at Chandigarh. He was the first President of the Palynological Society of India from 1967 to 1978, and Chairman, Governing Body of the Birbal Sahni Institute of Palaeobotany, Lucknow, from 1978-1981.

As early as in 1954 Mahabale was elected one of the Vice-Presidents of the Palaeobotany section of the VIII International Botanical Congress in Paris. Later he was invited to deliver special lectures at the IX and X International Botanical Congress at Montreal (1959) and Edinburgh (1964). As a member of the Indian delegation in 1962 he visited many Botanical Gardens of the U. S. S. R. and delivered lectures, also visited U. K., France, Belgium, U. S. A., Canada, U. S. S. R. and other countries on various occasions In recognition of his useful and sustained research work in Botany, he was awarded Birbal Sahni Gold Medal by the Indian Botanical Society in 1978.

As a close associate of Prof. S. P. Agharkar and as a Life Member Mahabale served the Maharashtra Association for the Cultivation of Science in various capacities, as Hony. Secretary, as member of the Executive Committee, as Council member and as Chief Editor of the MACS journal, Biovigyanam. After his retirement from the University of Poona he joined the MACS as Head of the Botany Department in 1971 and later continued as an Honorary Professor in the same Institute until his death.

Possessing a lovable, kind and affectionate nature Mahabale was greatly liked and admired by his students, associates, collaborators and colleagues A great teacher, he has left behind him a legacy of an old school charm and devotion of Indian traditional "Ashram" life. The end of this great Indian "Naturalist" came suddenly, unwarrented, on Sunday, 3rd July, 1983 at his residence when he was busy with the work of the second part of "Monographic studies on living and fossil palms of India" the first part of which having been just published. ☐

Sunirmal Chanda

NOTES & NEWS

On Environment

On June 5, World Environment Day, the Department of Environment, Government of India, brought out a book "*Indira Gandhi on Environment*". It includes a selection from the different addresses delivered by Prime Minister, Shrimati Indira Gandhi on various facets of the theme of environment from time to time. Beautifully illustrated and produced, this book has compiled most of her important comments on environment, conservation, ecological strategies, energy, forestry and preservation of wildlife. Most of the speeches were made in India and some at international gatherings. These reflect her deep concern and involvement with the subjects. In the preface, a brief outline has been given of her monumental contributions to the promotion of the concept of development without destruction.

The importance of maintaining ecological balance to sustain life on the earth had been known in the Country from 3000 B. C. or earlier. Texts in the Vedas recommended it. Later the Emperor Ashoka laid down specific guidelines for the conservation of wildlife.

The first concrete step undertaken by the Government of India, after independence, was in April 1972, with the establishment of the National Committee on Environmental Planning and Cooperation. At the inaugural address, included as the first article of this volume, "*Towards a better environment*", Shrimati Indira Gandhi had voiced her serious concern for maintaining the ecological balance and making preservation of Nature an integral part of developmental planning, "The ecological problems with which we are now concerned embrace diverse aspects ranging from the economic, social, psychological problems of human settlements to the management and use of natural resources and the conservation of natural habitats". She deplored the fact that though "Man is a part of nature and only one of the many species who inhabit the earth", yet "he has treated it as his colony to exploit it. The scale of. his intervention has now grown to a point where it has produced vast and disruptive changes which have already modified our existence more profoundly than any earlier human activity". She has stressed the preservation of nature together with the adoption of alternative means of livelihood for those dependent upon nature for survival. She then asked for a reassessment of the priorities in view of the price in terms of ecological degradation for the present and future generations.

At the plenary session of the United Nations Conference on Human Environments at Stockholm in June 1972, in an address on *Man and Environment*, she further developed the theme of alternative employment for tribals and others entirely dependent on nature for sustenance and warned against an absolute slant for conservation. According to her, "unless we are in a position to provide employment and purchasing power for the tribal people and those who live in or around jungles we cannot prevent them from combing the forest for food and livelihood".

> "The inherent conflict is not between conservation and development, but between environment and the reckless exploitation of man and earth in the name of efficiency".……
>
> "It is clear that the environmental crisis, which is confronting the world, will profoundly alter the future destiny of our planet. No one amongst us, whatever our status, strength or circumstance, can remain unaffected. The process of change challenges present international policies".…

"It has been my experience that people who are at cross purposes with nature are cynical about mankind and ill-at-ease with themselves. Modern man must re-establish an unbroken link with nature and with life. He must again learn to invoke the energy of growing things and to recognize, as did the ancients in India centuries ago, that one can take from the Earth and atmosphere only as much as one puts back into them".

While *launching the world conservation strategy in India*, in March 1980 the Prime Minister stressed "the need for a systematic campaign to educate governments, political parties, students from pre-school age onwards and others, regarding the importance and relevance of conservation and other factors involved. ……However, learned lectures on ecology and the sanctity of trees can have little meaning for vast numbers of our people unless we can guide them to other ways of financing their basic minimum needs. All those interested in implementing the World Conservation Strategy should give particular attention to technologies which can help to meet the daily needs of such people, especially in the rural areas.

Conservation cannot remain the responsibility solely of the Government. Official and voluntary agencies must work together to create greater awareness". She reiterated "the need to achieve growth in the economic and social well-being of people throughout the world within the confines of a sustainable environmental resource base".

At the fifteenth Regional FAO Conference at New Delhi in March 1980, in her address on *Grow more food with ecological harmony*, she outlined the importance of stimulating economic growth without damage to ecological harmony. Later, in August 1980, during the XVIII meeting of the Central Board of Forestry at New Delhi, while speaking on *Conserving our forests*, she observed that there should be a closer working partnership between science planning and administration. Even while reforesting areas, which have been or are to be used for industrial purposes, all aspects of conservation should be taken care of. She condemned the enactment of legislations which were not implemented.

In her inaugural address in January 1981 during the 68th Session of the Indian Science Congress at Varanasi, she again mentioned the need for balanced development related to environment. She observed that "the rich, out of greed and the poor, out of need, had been reckless in plundering earth's assets". There was now deep anxiety about the rapid diminishing of what have become essentials to our way of living, indeed even to life.

At the *United Nations Conference on New and Renewable* sources of Energy at Nairobi in August, 1981, while discussing *Nature and Energy*, Shrimati Gandhi said "We humans have regarded Earth not just as a playground but as a place to use, despoil and to destroy. We are too engrossed with the immediate, too absorbed with petty individual problems to look at basic issues. Today's problem has taken centuries to grow into its *present threatening proportions*"… …"We must view energy in its entirely, for problems of survival and progress are not pieces to be put together, but are inseparable parts of an integrated whole".

The address *A centenary of forest education in India*, delivered during the Centenary celebration of forest education at the Forest Research Institute and Colleges at Dehra Dun in December 1981, stressed "New thoughts and a sense of urgency combined with responsibility must be infused in our forestry policy and education. ......We must ensure that social forestry does not replace valuable old forests".

At the First National Conference for legislators on environment in New Delhi in April 1982, she hoped that the Parliamentarians would express their interest in environmental welfare not only in their functioning in Parliament or in State Assemblies, but also in their constituencies in trying to persuade people, specially the younger generation, about all aspects of conservation.

She observed at the Conference of State Forest Ministers at New Delhi in October 1982, during her talk entitled *Managing our forests* "the feeling that wildlife is only a matter of curiosity which can be preserved through ecological parks must go. Wildlife has to be wild and it has to survive". She mentioned the ill effects of leasing forests on contract basis, of mono-culture plantations and of clear-felling areas before starting plantation, without proper environmental planning.

The next two addresses, *Genetic research for the world's welfare* and *Science in the service of man*, were delivered at the inauguration of the XVI International Congress of Genetics at New Delhi in December and the 71st Session of the Indian Science Congress at Ranchi in January 1984 respectively.

The annexure I lists the different messages given on themes of environmental importance. These include : project tiger launch 1973, first global conference on the future 1980 ; wildlife week 1982 ; Indian edition of Mazingira 1983 ; World Environment Day 1984.

These messages illustrate her keen and abiding interest in conservation. She insists that ecological balance must be achieved but it should not be at the cost of any party—man, animal or tree. Included are also translations of Ashoka's pillar edict and Ashoka's rock edict. □

Archana Sharma

LETTERS TO THE EDITOR

Role of potassium cyanide in stomatal physiology of *Clematis gouriana* Roxb.

It is well known that stomatal aperture on the detached epidermis is influenced by the action of certain cations of the medium in which the peelings are incubated[1-3]. Cations especially the potassium ions are remarkable for the stimulation of stomatal opening in 'intact' or 'isolated' epidermal strips. But the effect of cyanide ions on the regulation of stomatal opening is not known so far.

The plant tissues vary in the response to cyanide. Cyanide inhibit a number of enzymatic reactions of cytochromes, peroxidases, catalases and phosphorylation[4]. Cyanide resistant respiration in higher plants[5] and microorganisms[6] was reported previously. The present study is aimed to show the effect of cyanide on stomatal regulation of *Clematis gouriana* Roxb.

The method employed in the present experiment is same as described earlier[7]. The histochemical detection of starch in guard cells was carried out by iodine staining and the detection of K^+ in the guard cells was performed by employing cobalt-sodium nitrate[8].

Figure 1 shows that stomates which were initially closed, opened to some extent in light when strips were floated on distilled water and the guard cells indicated a positive test for starch. In darkness, the stomates did not open and possessed dense starch.

The epidermal strips floated on potassium cyanide solutions (p^K=9.14) showed drastic action on stomatal opening. The maximum opening of stomatal aperture was induced in light by cyanide solution (1 mg/l) of p^H 9.16. The potassium cyanide induced open stomata showed the aperture to be as wide as 11.8± 2.1 μ. Peelings incubated in 1 mg/l potassium cyanide showed negative test for starch. In the dark, potassium cyanide did not help in the opening of stomata. As far as the detection of K^+ in guard cells was concerned, it was observed that in the closed or partially opened stomates, the potassium ions were absent whereas in fully opened stomata, potassium ions were detected. Accumulation of K^+ ions increase the osmotic pressure of guard cells, manifesting the opening of stomata. But the cyanide ions do have the important role to play.

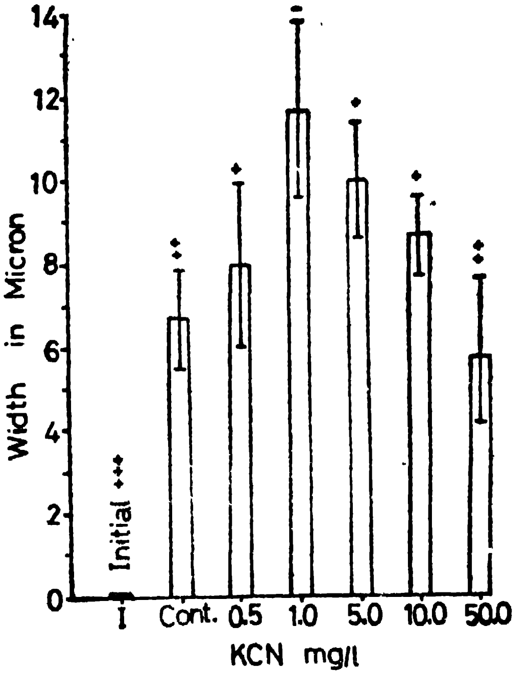

Fig. 1. Width of stoma in isolated epidermal strips of *Clematis gouriana* Roxb. treated with potassium cyanide or distilled water (Cont.). A test for starch is presented (— = absent, + = low, ++ = moderate, +++ = intense starch).

In the present experiment, the stimulation of stomatal opening in *C. gouriana* by potassium cyanide treatment is observed which may be due to cyanide insensitive enzymes[5,9] and cyanide provides conditions favourable for photophosphorylation ; the ATP molecules needed for stomatal movement are derived from the oxidative phosphorylation[9]. The ATP molecules may be required in the transport of malate and other organic acids into vacuole and uptake of potassium ions[9]. It seems from the present work that the opening of stomata may be due to the accumulative effect of potassium cyanide.

We are grateful to Dr. K. B. S. Dhillon, Principal, for facilities, Prof. H. C. Arora, Chemistry Department, for evincing interest and UGC for financial assistance.

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On the egg laying behaviour of the apple snail, *Pila globosa*

Pila globosa (Swainson) [Mollusca : Gastropoda] is an amphibious prosobranch snail, usually found in large numbers in the paddy fields during monsoon and in the ponds round the year. All the previous observations [1-3] and the present observations by the author point to the fact that monsoon influences the breeding of *Pila*. In Northern and Eastern India it extends from June to September[3], but in Bengal where the monsoon is early breeding takes place in May and June[1]. Females start the process of egg-laying, generally about two weeks after the onset of rains[3]. Though *P. globosa* is amphibious, water is essential for all of its biological activities except egg-laying. Thus, it passes its life mostly in water. The snails undergo aestivation by November or December when the field becomes dry, while those living in pond remain active as long as water is available.

The aestivated snails become active with the onset of monsoon. And within a fortnight they copulate. It is followed by egg-laying. In the paddy fields, the females select a site at the edge of the embankment preferably covered with bushy grasses or inside the interspaces of the soil chunks heaped on the embankment during preparations of the paddy field for cultivation. The pond-dwelling snails make a hole on the bank a few centimeters above the water margin. The female deposits eggs one by one in the selected spot. The eggs are rounded, white and calcareous. The eggs adhere with each other due to discharged mucus which after drying serves as an adhesive between the eggs. Thus, in *Pila* eggs are found only in cluster or in masses (Fig. 1) and never in isolated condition. In a cluster as much as ten rows of eggs are seen placed one above the other. As a rule, the egg masses remain attached to the substratum like soil, grasses or weeds.

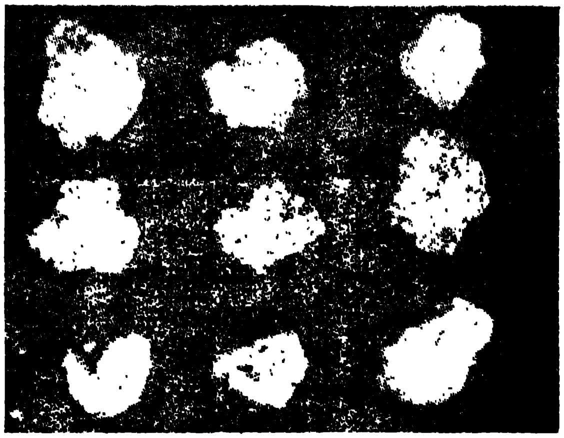

Fig. 1. Egg masses of *P. globosa*

Egg-laying takes place any time within a period of 24 hr. Ranjah[3], however, remarks that it generally lays eggs in the early hours of the morning. Although the snails breed during monsoon, they were never observed laying eggs while it was raining. Almost in all cases, the process of egg-laying follows a shower. The number of eggs varies with the egg masses. It ranges from 24 to 436. Ranjah[3], however, observes 100-850 eggs in the egg masses examined by him. On an average, it includes 178 (N= 255) eggs per brood. The size and structure of the eggs are same as observed by Prashad[1], Bahl[2] and Ranjah[3].

From the study of egg-laying behaviour, it appears that mucus helps in protecting the eggs from the damage during laying. It is only due to mucus the rolling of eggs is possible. The phenomenon of clusterization of eggs helps to protect the eggs from desiccation as well as in maintaining the moisture and temperature favourable for the development and hatching of the eggs. The selection of the edges of the embankment and the sites on the bank a few centimeters above the water surface of the pond for egg-laying most probably is associated with the availability of moisture for developing embryos and the easy movement of youngs to water following hatching. As the pond-dwelling snails lay eggs exclusively in monsoon, it is probable that monsoon is the only breeding season of this snail species. The halt to the egg-laying process, when it actively rains, saves the eggs from being washed away and helps in clusterization of eggs which increases the hatchability.

The findings suggest that *P. globosa* has adapted to lead an amphibious life successfully.

The author is thankful to Prof. K. C. Ghose, Department of Zoology, Calcutta University and to Dr. N. V. Subba Rao, Superintending Zoologist, Mollusca Section, Zoological Survey of India, Calcutta for their valuable suggestions and for kindly going through the manuscript.

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Effect of a benzyloxy compound on cocoon-shell weight following larval treatment in *Corcyra cephalonica* Stainton (Lepidoptera : Galleriidae)

Juvenile-hormone analogues or juvenomimetic compounds when applied to the last instar larvae of some Lepidoptera prolonged the larval life-span, increased food consumption, raised RNA and fibroin synthesis, resulted in a significant improvement of quality and quantity of the cocoon filament; thus recommendations have been made on their practical implication in sericulture[1-4]. The present work deals with the effect of a benzyloxy compound A13-63701, a non-terpenoid juvenile hormone mimic[5], on cocoon-shell weight after larval treatment in *Corcyra cephalonica*, a major pest of stored cereals.

The rearing conditions of *C. cephalonica*, method of application of the compound and procedure to evaluate the effect were same as described earlier[4].

The data of cocoon shell weight were summarised in Table 1. Benzyloxy compound

TABLE 1 : Weight of cocoon after the application of benzyloxy compound A13-63701. Range values are inside parentheses.

Doses (μg)	Weight Mean ± S. E. (mg)
100	316.83 ± 37.93 (214—601)
50	226.56 ± 19.12 (115—426)
10	18 .66 ± 26.54 (118—329)
1	43.66 ± 2.38 (26—63)
Control	36. 3 ± 4.81 (22–60)
C. D. at 1%	37.601
C. D. at 5%	28.614

AI3-63701 when topically applied to the 0-24-hr-old last larval instar of *C. cephalonica* increased the larval life-span 5-8 times. Food consumption was also increased significantly compared to controls. Active feeding, of course, lasted for about half of the total larval life period. All the experimental larvae underwent 2-4 extra moults. The giant supernumerary larvae, thus formed, built giant cocoons (Fig. 1) of increased weight differing significantly from the controls ($F = 137.051$, $P < 0.001$; d. f. 4, 145). Furthermore, the differences among doses were significant ($P < 0.01$). 1 μg treatment, however, produced no significant difference from control. The compound, AI3-63701 is much more effective than the other two compounds AI3-63629 and AI3-63604, reported earlier, in increasing weight of cocoon shell[4].

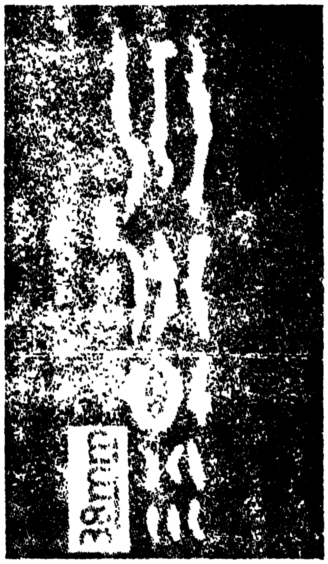

Fig. 1. Giant cocoons obtained after application of AI3-63701. First, second, third and fourth horizontal rows represent 100 μg, 50 μg, 10 μg and 1 μg dosage effects respectively; lower row-control.

Grateful thanks are due to Dr. A. B. Borkovec, Agricultural Environmental Quality Institute, United States Department of Agriculture, Maryland, USA for supplying the free sample of the compound and to CSIR, New Delhi, India for financial help through a grant-in-aid research scheme to SC.

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'Saroda' and 'Sukumari'—new rose cultivars evolved by gamma irradiation

A large number of gamma-ray induced new ornamental cultivars have been released by National Botanical Research Institute[1]. Two gamma-ray induced somatic flower-colour mutants of rose have been established as new cultivars and released as 'Saroda' and 'Sukumari'. In the present investigation, an attempt was made for spectrophotometric studies on pigments of mutants and their original cultivars.

'Saroda'—The mutant 'Saroda' was induced after exposure of budwood of rose, cv. 'Queen Elizabeth' to 3 kr of gamma rays. The mutant tissue detected in vM_1 was isolated and multiplied by repeated budding. 'Saroda' is a Blossom pink (very light pink) flower colour mutant of 'Queen Elizabeth' which produces Carmine-rose flowers. Spectrophotometric analysis of patal extracts showed the presence of three peaks (compounds) in 'Queen Elizabeth' and two peaks in 'Saroda'. The absorption maxima and their O. D. values have been given in Table 1 (Fig. 1 A).

TABLE 1 : Absorption maxima and O. D. values of individual compounds

Compounds	Absorption maxima (nm)				O. D.			
	'Queen Elizabeth' (1)	'Saroda' (2)	'America's Junior Miss' (3)	'Sukumari' (4)	(1)	(2)	(3)	(4)
1	520	—	520	—	.025	—	.025	—
2	350	350	350	350	.11	.20	.22	.46
3	270	270	270	270	1.12	.81	1.32	1.46

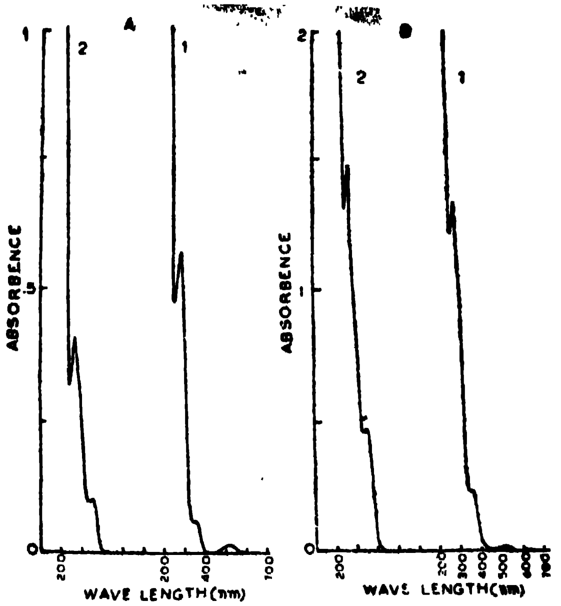

Fig. 1 (A and B). Absorption spectra of different compounds from petal extracts of original cultivars and their induced mutants (A—1 : 'Queen Elizabeth', A—2 : 'Saroda'; B—1 : 'America's Junior Miss', B—2 : 'Sukumari').

'Sukumari'—The mutant 'Sukumari' was induced after exposure of budwood of rose cv. 'America's Junior Miss' to 3 kr of gamma rays. The mutant tissue detected in vM_1 was isolated and multiplied by repeated budding. 'Sukumari' is a almost white flower colour mutant of 'America's Junior Miss' which produces Coral-pink flowers. Spectrophotometric analysis of petal extracts showed the presence of three peaks in 'America's Junior Miss' and two peaks in 'Sukumari'. The absorption maxima and their O. D. values have been given in Table 1 (Fig. 1 B).

Spectrophotometric analysis showed both qualitative and quantitative differences of the pigments between the original cultivars and their mutants. This indicates that the somatic flower colour changes might have been induced during pigment biosynthesis pathway.

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Effect of detergent on the somatic nuclei of *Allium cepa* L.

Among the different pollutants affecting our environment, two categories may clearly be recognised, namely natural and synthetic[1]. Synthetic pollutants, e.g. pesticides, detergents, pharmaceuticals, cosmetic products and plastic are continuously increasing with urbanization and industrial growth leading to environmental hazards. Sodium-lauryl-sulphate is one of the detergents used for biochemical experiments as well as for washing glass wares, etc. There is scanty report on the effect of this detergent on the nuclei. Therefore, the present study was undertaken to see the cytological effect of this detergent on the somatic nuclei of *Allium cepa*.

Onion bulbs with healthy roots were treated with four different concentrations of detergent (Fig. 1) at different time intervals along with control set for each type. The root tips were washed thoroughly after

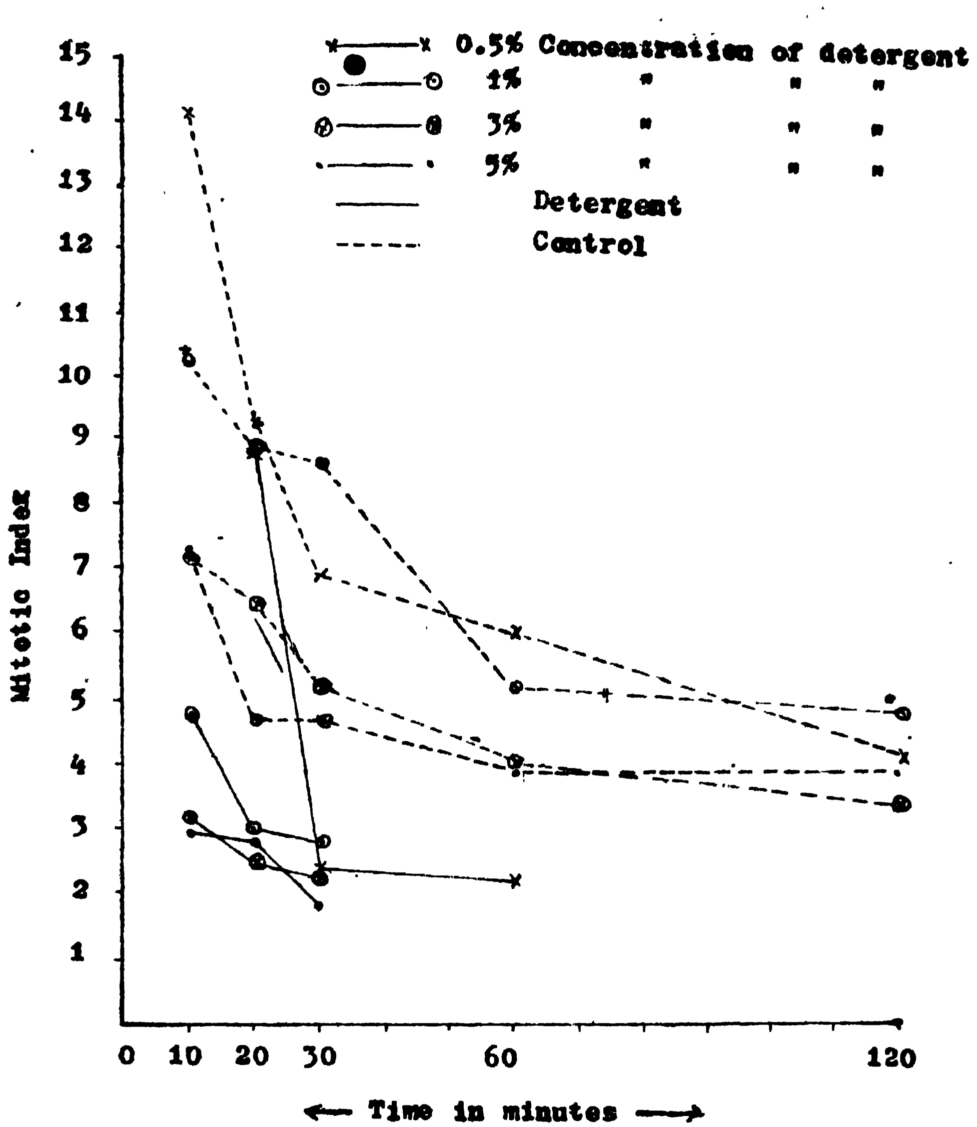

Fig. 1. Mitotic index of the somatic nuclei in the detergent treated and control sets

treatment and fixed in 1:3 acetic alcohol and squashed after staining in 2% aceto-orcein and NHCl (9:1).

Frequency of divisions was noted in all the four concentrations. There was a decrease in the value of mitotic index with the rise in the concentration of detergent. The divisional frequency was decreased with the increase in the time of treatment and ultimately resulted in inhibition of mitotic activity (Fig. 1).

Recovery of the treated root tips was done in Knop's solution at different times. It was seen that in lower concentration, i.e. 0.5% and 1% of detergent and less time of treatment there was recovery in the solution. When the concentration was increased to 3% and 5%, there was no recovery. This indicates that the detergent is harmful in nature. Another interesting feature noted was that with lower concentration and less time of treatment the abnormalities like sticky metaphase, chromatin bridge, fragmentation, nuclear lesions, polyploidy etc. were more, while with increase in the concentration of detergent, cell division as well as abnormalities decreased followed by mitostatic effect.

"t" test was done on mitotic index of the somatic nuclei; in both the detergent-treated and control sets and was found significant at 5% level. From this test, it was also quite clear that the mitotic activity of the detergent-treated nuclei was less compared to that of the control.

Evidently, sodium-lauryl-sulphate has definite cytological effects like other pollutants e.g., tobacco extract[2], industrial effluents[3], paper-mill effluents[4]. Abnormal cytological effects lead to genetical disorder in the long run. So it may be treated as another mutagen and one of the harmful synthetic pollutants. Their daily use should be properly cared to avoid water pollution and to save our living world from the hazards in the long run.

Pain and Smith[5] observed already in biochemical experiment that sodium-lauryl-sulphate destroys most biological functions, e.g. it denatures most protein to their subunits without breaking the covalent bonds. Therefore, they suggested that if one wishes to study enzymatic or antigenic properties of membrane components it is usually necessary to avoid sodium-lauryl-sulphate. This chemical destroys the biological functions which have been proved in the present experiment too.

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Presence of acidophilic iron and sulphur oxidising micro-organisms in uranium mine sludge of Jaduguda

Leaching bacteria, commonly known as *Thiobacillus ferrooxidans*, have now been universally accepted as a biological catalyst in oxidising low-grade sulphidic ore of different metals. There is plenty of literature on the microbial leaching of uranium ore too, where insoluble tetravalent uranium gets oxidised to soluble hexavalent uranium[1, 2]. Barbit and others[3] have utilised *T. ferrooxidans* present in uranium ores and mine water for leaching of waste uranium materials. Manchee[4] reported about 94% recovery of uranium from Canadian uranium ores by bacterial-leaching process. Guay and others[5] recorded 68% uranium extraction in 9 days by bacterial process. Derry[6] and others obtained about 95% extraction from ore containing 0.12% U O_8 on pilot plant scale based on bacterially assisted process. There is a report of producing a million pounds of U_3O_8 a year, using 3,000 tonnes of crushed ore per day by bacterial process. Thus, it is seen that bacterially-assisted uranium leaching process[7] has reached to the commercial scale and this biological-leaching method could be a cost-competitive alternative method for uranium recovery[8].

Keeping in view the vital role played by these leaching organisms in the solubilisation of base metals from low-grade sulphidic ores, it was considered worthwhile to find out their presence in the uranium sludge of Jaduguda Uranium Mines, Singhbhum, Bihar.

Leathen's[9] media was used for the growth of the micro-organisms. pH was adjusted between 2.0-3.0 by the addition of dilute sulphuric acid. The sludge was filtered through Whatman No. 4 filter paper and the filtrate was enumerated for initial cell counts in Neubauer double counting haemacytometer. This filtrate was used as inocula in experimental investigations.

Three set of experiments were started in 500 ml Erlenmyer flasks as mentioned hereunder.

Set-I : It contained 250 ml of Leathens media + 2.5 g ferrous sulphate + 2.5 g elemental sulphur + 5.0 ml of uranium sludge filtrate after boiling + 5.0 ml of 5% mercuric chloride as bactericide. The amount of ferrous in the media would be approximately 0.2%. This set will be termed as control set. C. L. Brierley[10] has used 0.2 m M panacide (2, 2-methylene bis (4-chlorophenol) as bactericide in biogenic extraction of uranium from ores.

Set-II : It contained 250 ml of Leathen's media + 2.5 g of ferrous sulphate + 2.5 g of sulphur + 5.0 ml of uranium sludge filtrate as inocula. This experiment was performed for the evaluation of *T. ferrooxidans*.

Set-III : It contained 250 ml of Leathens media + 2.5 g of sulphur + 5.0 ml of uranium sludge filtrate as inocula. This experiment was performed for the evaluation of *T. thiooxidans*.

Set-II R : After 2 days of incubation in Set II, iron oxidation from ferrous to ferric became stagnant hence 5.0 ml inocula of this grown culture was seeded to another Leathen's media. This set will be termed as Set-II R (recultured).

All the above four sets were kept in incubator at 30-32°C for growth. Bacterial counts in all sets were done as mentioned earlier. Ferrous iron analysis in Set I, II, and II-R was performed by standard permanganate method[11]. Change in p^H in all the four sets was measured by p^H meter. Change in acidity was measured by titrating 1.0 ml of culture medium with N/100 sodium hydroxide solution.

In Set II containing 5.0 ml of uranium sludge and both ferrous sulphate + elemental sulphur, total oxidation (100%) of ferrous had taken place in 15 days. The rate of oxidation remained stagnant from 2 to 9 days but later on it increased rapidly. Under similar conditions in the control Set-I containing mercuric chloride, only 22.64% oxidation had taken place. This revealed that the enhanced oxidation of 78.36% of ferrous iron was due to the presence of iron- and sulphur-oxidising bacteria present in the ore sludge. When this grown culture was re-inoculated in fresh Leathen's media (Set-II-R), the rate of ferrous oxidation was comparatively slow up to 6 days which started increasing and complete oxidation was observed in 10 days instead of 15 days as in Set-II.

The results of oxidation of ferrous iron to ferric iron has been shown in Fig. 1. The experiment indicates that reculturing of the culture from the Set-II to the Set-II R further improves the biochemical activity of the bacteria and that is why 0.2% ferrous iron gets oxidised to ferric iron in 10 days instead of 15 days in the Set-II.

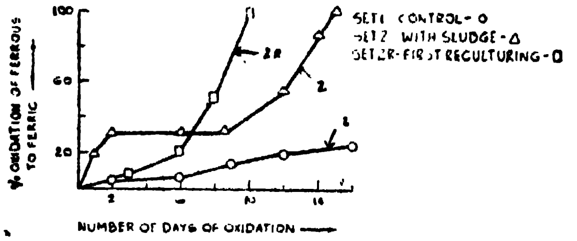

Fig. 1. Oxidation of ferrous to ferric iron with bacteria present in uranium sludge *(Thiobacillus ferrooxidans)*

The results of increase in cell counts has been shown in Fig. 2. Initial cell counts in the Set I, II and III were nil. In Set-II R which contained inocula from Set-II, the initial cell counts were 0.0105×10^7 cells/ml. After 16 days of incubation in the control Set-I, the cell counts increased to 0.3×10^7 cells/ml (curve 1) which is parallel to the base line. In the Set II where uranium sludge was used and both ferrous sulphate and sulphur had been used as energy sources the number of viable cells increased to 260×10^7 cells/ml in 16 days (curve 2). In the Set-III where uranium sludge was used and only sulphur was used as energy source, the number of viable cells increased to 8.3×10^7 cells/ml in 16 days of incubation (curve 3). In the Set-II R which contained inocula from Set-II, the number of viable cells increased to 240×10^7 cells/ml in only 10 days of incubation (curve 4).

It is, therefore, inferred that uranium sludge does not contain much population of sulphur-oxidising bacteria of *T. thiooxidans* type. But it contains appreciable amount of iron-oxidising bacteria of *T. ferrooxidans*

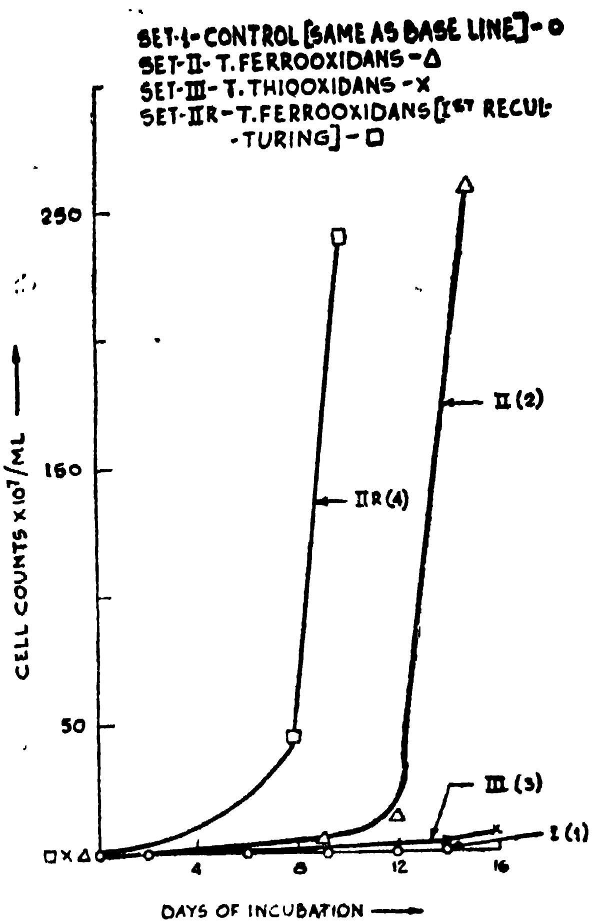

Fig. 2. Increase in cell counts in the media

type. The results also show that reculturing not only improves the biocatalytic activity but biogenic multiplication rate is also improved.

Set-III indicates the catalytic biochemical activity of sulphur-oxidising bacteria of *T. thiooxidans* type. In 16 days of incubation, the decrease in p^H is from 2.8 to 2.0 which has resulted in an increase in acidity from an initial of 0.5 ml to 1.0 ml.

The investigations made in the laboratory reveal that uranium sludge of Jaduguda contains iron- and sulphur-oxidising bacteria of *T. ferrooxidans* type. The population of sulphur-oxidising bacteria, i.e. *T. thiooxidans* is quite low. The culture of *T. ferrooxidans* gets further improved after reculturing. The enriched culture has faster rate of oxidation of ferrous iron to ferric iron and multiplies into more cells.

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Origin of barite deposits of Vemula area, Pulivendula Taluk, Cuddapah dist., A. P.

A large number of barite deposits occur in the Vemula area (lat. 14°23′, long. 76°16′) of Cuddapah district at the contact of Vempalle dolomitic limestone and trap, Pulivendula quartzite and trap as well as within the trap and rarely in the Tadpatri shale of lower Cuddapah Supergroup. The barite veins often show pinching and swelling ; they run in an east-west direction with a southernly dip ranging between 65° and 85°.

Spectrographic analysis of barite samples, using Jarrel—Ash 1 1.5 meter D. C. Arc instrument, has been carried out for 31 elements down to the approximate lower limit of detection (Table 1).

A high content of Fe in some of the samples is due to the presence of pyrite and chalcopyrite. Chalcopyrite occurs as disseminations, specks and blebs distributed irregularly in the barite. Idiomorphic pyrite grains are seen at the contact of barite and quartz. The high concentration of Mg and Ca in Item No. 11 is due to fact that the barite samples comes from a dolomitic lime-

TABLE 1 : Spectrochemical Data of Vemula Barite

Item	11	12	13	14	15	16	17	18	19	20
Element										
Fe	1%	0.05%	0.5%	0.05%	0.05%	0.05%	0.05%	1.5%	2%	0.2%
Ca	20%	0.03%	0.1%	0.05%	0.02%	0.02%	0.02%	0.15%	0.5%	0.02%
Mg	10%	0.1 %	0.5%	0.07%	0.02%	0.07%	0.02%	3%	5%	0.7 %
Ag	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
As	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500
B	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Be	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Bi	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cd	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Co	5	<5	<5	<5	<5	<5	<5	5	10	<5
Cr	20	<10	20	<10	<10	10	<10	300	10	50
Cu	30	15	2000	5	70	5	<2	20	3	500
Ca	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Ce	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
La	20	20	20	20	20	20	20	20	20	20
Mn	700	<10	10	<10	<10	<10	<10	200	500	50
Mo	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Nb	20	20	20	20	20	20	20	20	20	20
Ni	<5	<5	<5	<5	<5	<5	<5	70	<5	5
Pb	10	<10	<10	<10	<10	<10	<10	10	<10	<10
Sb	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Sc	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Sn	10	10	10	10	10	10	10	10	10	10
Sr	500	7000	3000	5000	3000	3000	7000	2000	3000	5000
Ti	200	<20	100	<20	<20	50	<20	1500	3000	300
V	10	10	10	<10	<10	<10	<10	70	100	15
W	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Y	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Zn	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
Zr	<20	<20	<20	<20	<20	<20	<20	20	20	<20

Item No.	*Sample No.*	*Sample Environment*	*Item No.*	*Sample No.*	*Sample Environment*
11	=MPB 200	Lst	16	= MRKB 37	Trap
12	=MPB 310	Trap-Lst-contact.	17	= SRB 92	Trap-Qtz-contact.
13	=TAB 362	Trap	18	= DKB 400	Trap
14	=TAB 360	Trap-Qtz-contact.	19	= MRKB 40	Trap
15	=DKB 392	Trap	20	= KAB 3	Trap-Qtz-contact

NOTE : Unless and otherwise indicated all values are in ppm

Lst=Lime Stone; Qtz=Quartzite

stone environment. The presence of Mg and Ca in other samples is due to the presence of calcite as medium to fine, subhedral to anhedral grains randomly distributed in the samples.

From Table 1, it will be seen that there is a close relationship between the distribution of Fe and Ti. Price and Duff[1] and Straus[2] have indicated that the high content of Ti is suggestive of a volcanic environment. Vanadium is present in small quantities. Ringwood[3] has suggested the chances of its occurrence are high in a residual magma.

Strontium is intermediate in size between Ca and Ba and exists as a free ion in magmas. The concentration of strontium in the calcium-bearing minerals is relatively high in late magmatic fraction[4]. Vlasov[5] has considered that the Ba-Sr isomorphism is particularly characteristic of hydrothermal processes. On the basis of abundance of strontium, Reddy and Sriramdass[6] have attributed barite deposits east of Khammam to the action of residual solutions. Vyas Rao and Murthy[7] who examined the barite deposits near Pulivendula are also of the opinion that the mineralising solutions might have come from a magma of deep-seated origin. The trace element data, therefore, indicate that the present deposits have formed from residual solutions.

The trace element data of trap-rock samples[8] show a high range of barium content (300-17000 ppm) which is higher than the reported values[9-11]. This could suggest that originally the magma of Vemula area was rich in barium. Considering that in magmatic solutions the content of NaCl is more than 1 mole (58.7 g/kg), barite can precipitate during simple cooling of most hydrothermal solutions[12]. As the differentiation of magma in Vemula area progressed, the residual solutions became enriched in barium and with simple cooling precipitation of barium sulphate took place.

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Influence of some growth regulators *in vitro* on the pollen growth of *Cicer arietinum*

Flower withering and shedding, failure of fertilization of all the ovules resulting in partially filled fruit and low percentage of seed set are apparently major causes of poor yield in food legumes[1]. One of the important biological factors in determining the yield of the crop is pollen germination and pollen-tube elongation. A study of growth regulators on the pollen growth of *C. arietinum* L. *in vitro*, has, therefore, been undertaken to have better understanding of this aspect.

C. arietinum cv. BG 203 was grown in pots in the winter of 1981-82. For germination studies, pollen-grains were collected from flowers that anthesized the same day in the field. Their germination has been carried out by 'hanging-drop technique' in Brewbaker and Kwack's medium[2] at 24±2°C in diffuse light. The percentage of germination and tube elongation was noted after 2 and 4 hr of germination.

Table 1 shows the percentage of pollen germination and pollen-tube elongation in culture medium supplemented with different concentrations expressed in ppm with respective growth regulators. Of the studied regulators; IAA (1; 10) ; GA$_3$ (1, 10) ; NAA (10) ; TIBA (10) ; KIN (1, 10) ; and CCC (100) stimulated the germination significantly over control whereas a decrease in germination was reported by ethrel (100), IBA (10) and morphactin (1; 10). The maximum increase and decrease in germination was indicated by IAA (1) and morphactin (10) respectively.

Stimulation of pollen-tube elongation was reported by GA$_3$ (1, 10) ; IAA (1, 10), NAA (10) and KIN (1) whereas IBA (10); TIBA (10), KIN (10) ; morphactin (1, 10), ethrel (100) and CCC (100) suppressed it significantly. There was maximum pollen-tube elongation and suppression than controls as well as other growth regulators with both the concentrations of GA$_3$ and ethrel respectively. TIBA (10), KIN (10) and CCC (100) prompted the germination but suppressed the growth of the pollen tube. IAA (1; 10); GA$_3$ (1, 10); KIN (1) and NAA (10) enhanced both the germination as well as pollen-tube elongation.

Different growth regulators thus reacted variously on pollen germination and pollen-tube elongation. Similar trend in *Arachis hypogea*[3] led to the suggestion that pollen germination and tube elongation were two distinct processes.

TABLE 1 : Effect of growth regulators *in vitro* on pollen growth of *C. arietinum*

Growth regulators	Concentration (mgl^{-1})	% Pollen germination after		Pollen tube length (μ) after	
		2 hr	4 hr	2 hr	4 hr
Control	0.0	44.5±1.4	61.1±2.7	138.0±6.0	199.6±6.6
IAA	1	80.4±3.4	85.4±5.2	238.6±9.0	326.2±18.1
IAA	10	50.3±4.7	78.5±1.7	216.4±30.0	367.0±39.4
IBA	10	32.8±2.8	58.5±6.8	98.2±7.5	146.2±13.2
NAA	10	77.5±2.9	85.0±2.0	200.2±8.5[a]	267.0±14.4
TIBA	10	64.1±3.9	83.3±2.6	88.5±7.9	167.0±12.3
Kinetin (KIN)	1	78.8±5.5	83.3±3.2	206.2±13.8	337.8±18.1
Kinetin	10	33.7±2.4	67.9±1.1	117.3±8.8	180.0±8.5
GA$_3$	1	58.9±4.3	62.3±6.8	611.7±60.2	630.64±53.2
GA$_3$	10	53.2±5.0	67.2±6.7	447.2±56.0	650.3±70.0
Morphactin	1	38.6±3.1	51.53±4.6	94.6±6.3	120.1±10.2
Morphactin	10	33.8±1.9	45.07±4.1	74.5±7.5	96.8±8.9
Ethrel	100	37.9±3.6	46.3±2.5	11.45±1.4	16.9±1.1
CCC	100	62.37±3.9[a]	67.4±4.3	28.4±1.3	36.9±1.6

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Screening of some plant extractives for antifungal activity against *Venturia inaequalis*

Apple, the fruit of considerable economic importance, is susceptible to a fungal infection, viz. 'apple scab' (*Venturia inaequalis*). The chemical fungicides presently in use to control the fungal infection are, however, not free from the harmful residual toxicants—the potential source of environmental pollution ! Attention of agricultural chemists is drifting slowing towards the use of herbal fungicides. since these are bio-degradable and thus cause no disturbance in the ecosystem. With this objective in view, the authors have screened thirty-two plant extractives for their antifungal activity against the spores of *Venturia inaequalis*, using agar as a nutrient medium. The following twenty-two plant extractives showed inhibitory activity against the aforesaid fungus :

Allium sativum Linn. (bulb) ; ***Artemisia maritima*** Linn. (leaves) ; ***Berberis lycium*** Royle (roots) ; ***Camellia sinensis*** Linn. (leaves) ; ***Capsicum annuum*** Linn. (fruit) ; ***Cassia fistula*** Linn. (leaves) ; ***Curcuma longa*** Linn. (rhizome) ; ***Datura stramonium*** Linn. (leaves) ; ***Euphorbia helioscopia*** Linn. (whole plant) ; ***Ferula foetida*** Regel (gum resin) ; ***Juglans regia*** Linn. (young fruit) ; ***Lawsonia alba*** Lam. (leaves) ; ***Peganum harmala*** Linn. (seeds) ; ***Podophyllum emodi*** Wall ex Hook. f. & Th., (rhizome) ; ***Sapindus mukorossi*** Gaertn. (fruit shell) ; ***Terminalia bellirica*** Roxb. (fruit) ; ***Terminalia chebula*** Retz. (fruit) ; ***Thuja orientolis*** Linn. (fruit) ; ***Thymus serphyllum*** Linn. (seeds) ; ***Urtica dioica*** Linn. (leaves) ; ***Viola odorata*** Linn. (whole plant) and ***Zingiber officinale*** Rosc. (rhizome).

Under the same conditions the following plant extractives, however, were found to be inactive : *Acorus calamus* Linn. (rhizome) ; ***Aesculus indica*** Colebr. (fruit) ; ***Cassia fistula*** Linn. (pulp from the pod) ; ***Chrysanthemum cinerariaefolium*** Vis. (flowers) ; ***Commiphora mukul*** Hook. ex Stocks (oleo-gum-resin) ; *Nicotiana tabacum* Linn. (leaves) ; ***Pinus longifolia*** Roxb. (fruit) ; ***Plantanus orientalis*** Linn. (leaves) ; ***Salix alba*** Linn. (leaves) ; and *Saussurea lappa* C. B. Clarke (stem).

The spores of the fungus were collected during the month of June and July 1981, from the nearby apple orchard, in Naseembag area, Srinagar.

The plant material was extracted for 8 hr with methanol, in a Soxhlet apparatus. The evaporation of the solvent, under reduced pressure, yielded a residue which was tested for its antifungal activity according to the method described in literature[1,2]. Thus, a suitable amount of molten agar medium, in a sterile petri dish, was mixed thoroughly with the plant extractive. The fungal spores were streaked on the solidified agar and subsequently incubated for 24 h. The inhibition of growth of *V. inaequalis* was determined by comparing it with the amount of growth of control plate (without the extract)—incubated likewise as the test agar-plate.

The authors wish to thank Prof. W. U. Malik, Prof. J. Shanker, Dr. A. M. Shah and Dr. S. Joshi for their interest in this investigation and to Miss Q. Bilquis, Mrs. S. Handoo and Mr. M. A. Zargar for their assistance.

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Studies on a mosaic disease of cowpea from Uttar Pradesh

Cowpea (*Vigna unguiculata* L.) is an important legume crop grown in zaid and kharif seasons in the states of northern India. The crop is a good source of green cattle-feed and protein rich vegetable to the common man. For the last several years, a mosaic disease on cowpea varying in incidence from 15 to 56 per cent at several places in Uttar Pradesh, was observed to cause great damage to the foliage and grain yield. This paper reports on the identity of the virus, nature of loss and possibility for its control.

The disease material collected from different places in Uttar Pradesh during 1981, was used to study the properties of the virus using standard procedures[1]. Loss estimates with respect to foliage, pods and grain yield were made in 10 paired plants (diseased and healthy) selected randomly in the field plot at glass house yard of C.S.A. University of Agriculture & Technology, Kanpur. Data taken on plant height, plant weight (foliage and stem) just before flowering and that on number of pods and grain yield at the time of maturity were analysed statistically and differences compared.

The disease was found mechanically transmissible and in addition to 10 varieties of cowpea, it infected *Crotalaria juncea* L., *Glycine max* (L.) Merr., *Phaseolus calcaratus* L., *P. lunatus* L., *P. vulgaris* L., *Vigna mungo* (L.) Hepper., *V. radiata* (L.) Wilczek. and *V. sesquipedalis* L., producing mild to moderate mosaic symptoms. It induced necrotic local lesions on *Chenopodium amaranticolor*, Coste & Reyn. However, *Nicotiana tabacum*, *N. rustica*, *N. glutinosa*, *Datura stramonium*, *Petunia hybrida*, *Cucumis sativus*, *Dolichos lablab*, *Zinnia elegans* and many others in 10 different families could not be infected.

Three aphids—*Aphis craccivora* Koch., *A. gossypii* Glov., and *Myzus persicae* Sulz. —transmitted the disease non-persistently. *Acyrthosiphon pisum* Harris, however, did not transmit the disease in similar tests. The disease was found to be seed-borne in cowpea vars. T2 (3%), Co4 (6%) and 5269 (18%) of the four varieties tested by collecting 100 seeds from the infected plants of each variety and growing them in sterilized soil in an insect proof glass house. Cowpea variety couv-2 did not show seed transmission.

The virus survived a dilution of $1 : 10^3$ but not $1 : 10^4$, a temperature of 55°C but not 60°C for 10 min and had longevity in crude sap for 24 hr at room temperature (20°C±2). The virus gave positive reaction with cowpea mosaic antiserum in chloroplast agglutination test[2]. No reaction, however, was obtained in similar test conducted with antisera of bean common mosaic, bean-yellow mosaic, and cucumber-mosaic viruses. These studies confirmed the virus to be an aphid-transmitted seed-borne cowpea-mosaic virus resembling one earlier reported from Delhi[3].

The disease caused significant loss in plant height, weight, number of pods and grain yield (Table 1).

The losses shown in Table 1 seemed to be obligatory to the growers as the disease is seed borne. During surveys, it was noted

TABLE 1 : Loss in yield components of cowpea var. T2 caused by mosaic disease

Category of plants	Av. Plant height in cms		Av. weight/ plant in gms	R	No. of pods/ plant	R	Av. grain yield/plant in gms	R
Healthy (H)	70.7	—	30.6	—	19.2	—	6.4	—
Diseased (D)	30.2	58.45	8.0	73.85	5.2	72.9	2.4	62.5
't' value for H and D	—	4.14**	—	2.89**	—	18.91**	—	59.97**
't' value at 5%	—	2.26	—	2.26	—	2.26	—	2.26
't' value at 1%	—	3.25	—	3.25	—	3.25	—	3.25

R = reduction ** = values significant

that aphid infestation of cowpea was not a common feature and thus their role in spreading this disease does not seem to be vital. The virus-laden seedlots play an important role in the epidemiology of this disease. The disease and the losses can be avoided through using virus free seedlots preferably from non-seed-borne cowpea cultivars.

The authors are grateful to the Professor and Head, Department of Plant Pathology, C. S. A. University of Agric. & Technology, Kanpur for facilities and to Dr. L. Bos, Wageningen, The Netherlands for the supply of antisera.

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On the phenograms of dominant weeds from West Bengal's industrial belt

The coal-steel-fertiliser complex, embracing the district of Burdwan, harbours a distinct type of weed community not evident in West Bengal or in other States for that matter. On the basis of their density and frequency of occurrence, as determined by the quadrat method of Lemon[1], eight species were found to be dominant in the sprawling industrial belt. These species can be conveniently divided into two groups, viz. leguminous weeds and non-leguminous weeds. Among legumes, *Cassia sophera* L. and *C. tora* L. are woody shrubs and *Desmodium triflorum* DC. trailing herbs. *Malachra capitata* L. and *Sida acuta* L. are examples of erect upright herbs among non-legumes, while the rest are prostrate dorsiventral herbs. *Evolvulus nummularius* (L.) L. is a creeping herb, being rooted at the nodes. *Tribulus terrestris* L. is a stiff procumbent herb, forming large circular patches in the ground by the characteristic development of lateral branches. Each of the various weeds thus possess specialised habit of their own making and contribute to their unique ecophysiology. Regular phenological observations are a must to study the various phases in the life-cycle of a weed from their emergence through seeds or appearance through perennating root stocks until death intervenes. Such observations can be recorded in the form of phenograms as done by Sen[2]. While data exist for weeds inhabiting western part (Rajasthan) of the country, there is very little or no mention of plants from the eastern counterpart (West Bengal).

The present account on phenograms is based on observations of the above species in four selected regions—Asansol, Durgapur, Jambad and Raniganj—in Burdwan district.

All the weeds are rainy-season therophytes (Fig. 1) amongst which *Trianthema portulacastrum* and *Tribulus terrestris* complete their life-cycles much ahead of others. Their vegetative growth starts at the onset of monsoon in comparison with *Cassia sophera*, *C. tora* and *Desmodium triflorum* where the process is initiated late. With the progress of the season, both *Trianthema* and *Tribulus* appear to bloom. In other weeds, flowering begins later than these two plants. Among the rest, flowering is greatly delayed in *C. sophera* and *Evolvulus nummularius* and held after the monsoon is over. Whereas *C. sophera* starts to produce fruits in the post-monsoon season, other species do the same during the full force of monsoon. By the time *Trianthema* is on the wane, seeds of *C. sophera* commences to mature; these events herald the advent of winter. In two species of *Cassia* and *Tribulus terrestris*, plant senescence occurs quite late as compared to other species. Among them, *Trianthema* disappears earliest from the scene. In

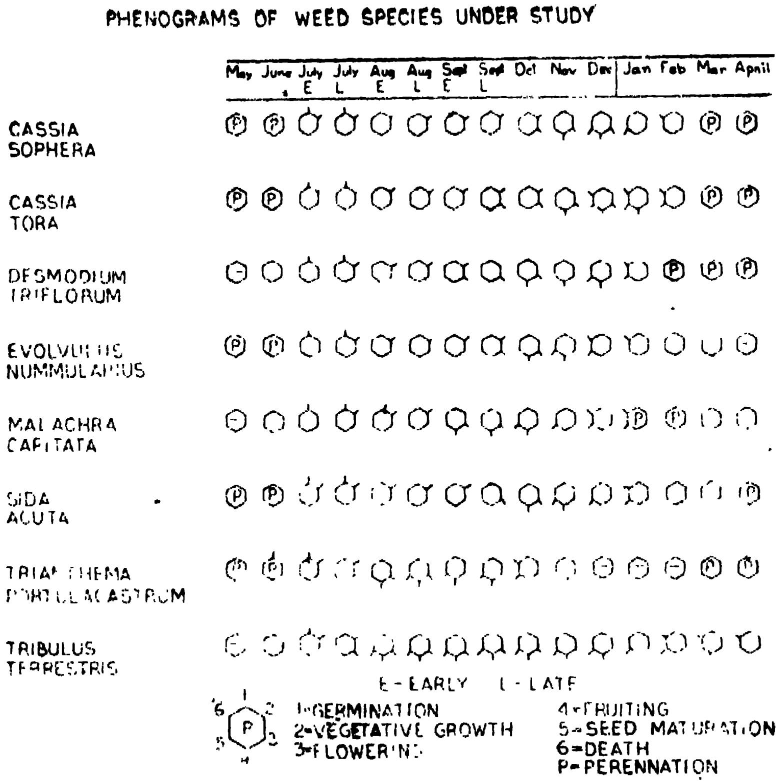

Fig. 1.

sharp contrast, *Desmodium* and *Tribulus* linger for an extended period. Though the vegetative and reproductive growth of *Trianthema* and *Tribulus* coincide with each other, the former does not persist in the fields as long as the latter. Interestingly enough, *C. sophera* is late in flowering and fruiting. It is not available in the four regions as long as *Desmodium* where vegetative and reproductive growth take place earlier.

The phenogram on *Tribulus terrestris* is in accord with that presented by Sen[2]. The phenograms on other species (are new for the country) and which carry on dual reproduction[3], sexual (seeds/fruits) and vegetative (perennating root stocks). The eight dominant weeds are thus capable of reproducing in more than one way and are potentially dangerous. Phenological approach can provide a better understanding of these weeds and offer clues for safer and more effective control.

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Effect of liming and manuring on the herbage yield of *Leucaena leucocephala*

Leucaena leucocephala L. is a leguminous plant and was being maintained in Agrostology nursery at Agricultural Research Institute, Kanke, since 1958. Its tender leaves and twings are used as forage for farm animals (e.g. sheep, goats and cattle), the leaves are also fed to poultry birds. Considering its wide scope for growing on the eroded uplands in the hilly region of Chotanagpur in Bihar, it was essential to test the effects of liming and manuring on its herbage yield.

Uplands soils of Chotanagpur are red yellow in colour, low in organic matter, nitrogen and phosphorus content and acidic in reaction. Therefore, liming of soil is done to raise its pH to enable the soil to release more plant nutrients for growth. Leguminous plants require more plant nutrient than grasses and respond to liming. Therefore, an experiment was conducted in Agrostology nursery at Ranchi Vet. College to test the effect of liming alone, manuring alone, liming plus manuring, and control (no liming and no manuring) with four replications. *L. leucocephala* was sown in July 1978, it established well by 1979. Preliminary data obtained in 1978 and 1979 have been omitted.

Liming has been done every year before the onset of monsoon rains in May-June at the rate of 2.5 tonnes per hectare. Organic Farm-yard manure and nitrogen and phosphatic fertilizers were applied in the beginning years. During the period of study (1980-1982), only fertilizers of Urea and single super-phosphate has been applied to supply nitrogen and phosphorus at the rate of 20 kg N plus 50 kg P_2O_5/ha in the manuring treatments before the rainy season. The data have been analysed annually and pooled analysis of the data has been also done.

Effect of liming has been found significant in all the years and also in the pooled analyses. The yield obtained are presented in Table 1.

Application of lime has significantly increased the yield in all the three years (1980-82) and in the pooled analysis, but the percentage increase has decreased from 1980 (108%) to 1981 (88%) and to 1982 (52%). On the whole 76% increase in herbage yield has been obtained in the mean yield.

The effect of manures and fertilizers have been found significant in 1980 and in the pooled analysis. The yield are given in Table 2.

TABLE 1: Effect of liming on herbage yield Q/ha

Treatment	Yield/year			
	1980	1981	1982	Pooled mean
Unlimed	112.17	165.83	220.52	166.83
Limed	233.19	312.08	335.48	295.26
S. Em ±	22.76	32.83	35.58	17.72
C. D.	72.79	105.43	113.82	51.50

TABLE 2: Effect of manures and fertilizers on herbage yield (Q/ha)

Treatment	Yield/Year			
	1980	1981	1982	Pooled mean
Control	115.09	190.94	239.68	182.27
Manured	231.29	266.98	315.31	277.97
S. Em ±	22.76	32.33	35.58	17.72
C. D.	72.79	NS	NS	51.5

Manure and fertilizers significantly increased the yield in 1980 by 10% and in pooled analysis by 53%. The effect in 1981 and 1982 are not significant. It seems that as the plant grow in age, its root goes deeper and surface application of fertilizers on the soil is not utilized by the deep roots.

The effect of interaction (liming/manuring) has been not significant in any year, but the pooled analysis shows the significant effect, indicating that liming and fertilizer application have different response which have been revealed in the pooled analysis. The yield data and percentage increase over control are presented in Table 3.

In all the year highest yield has been given by combined application of lime plus manure. In 1980, the p. c. increase by application of manure alone has been higher than lime alone. In 1981 and 1982, liming has given higher percentage increase than manuring. In the combined application of

TABLE 3 : Effect of interaction L x M on herbage yield (Q/ha)

Treatment	Year							
	1980		1981		1982		Pooled Mean	
Combination	Yield	P.C. increase over control	Yield	P.C. increase over control	Yield	P.C. increase over control	Yield	P.C. increase over control
Control	91.21		155.42				150.61	
Lime alone	114.15	25	226.46	46	274.17	34	213.92	42
Manure alone	133.12	46	176.25	25	235.83	15	183.06	22
Lime plus manure	325.29	257	397.71	156	394.79	92	372.92	148
S. Em +	32.17		45.65		50.34		25.07	
C. D.	NS		NS		NS		72.67	

lime plus manure the increase in yield over control has decreased from 251 p.c. in 1980 to 92 p.c. in 1982. An increase of 148 p.c. in pooled data has been observed.

Hence, combined application of liming and manuring is more effective than application of lime or manure alone.

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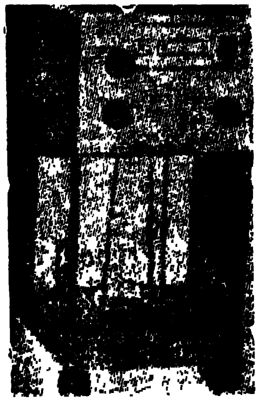

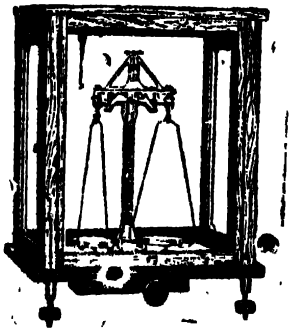

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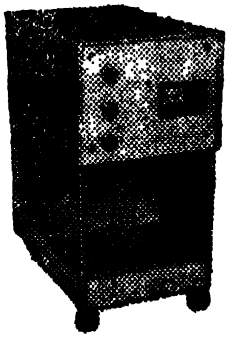

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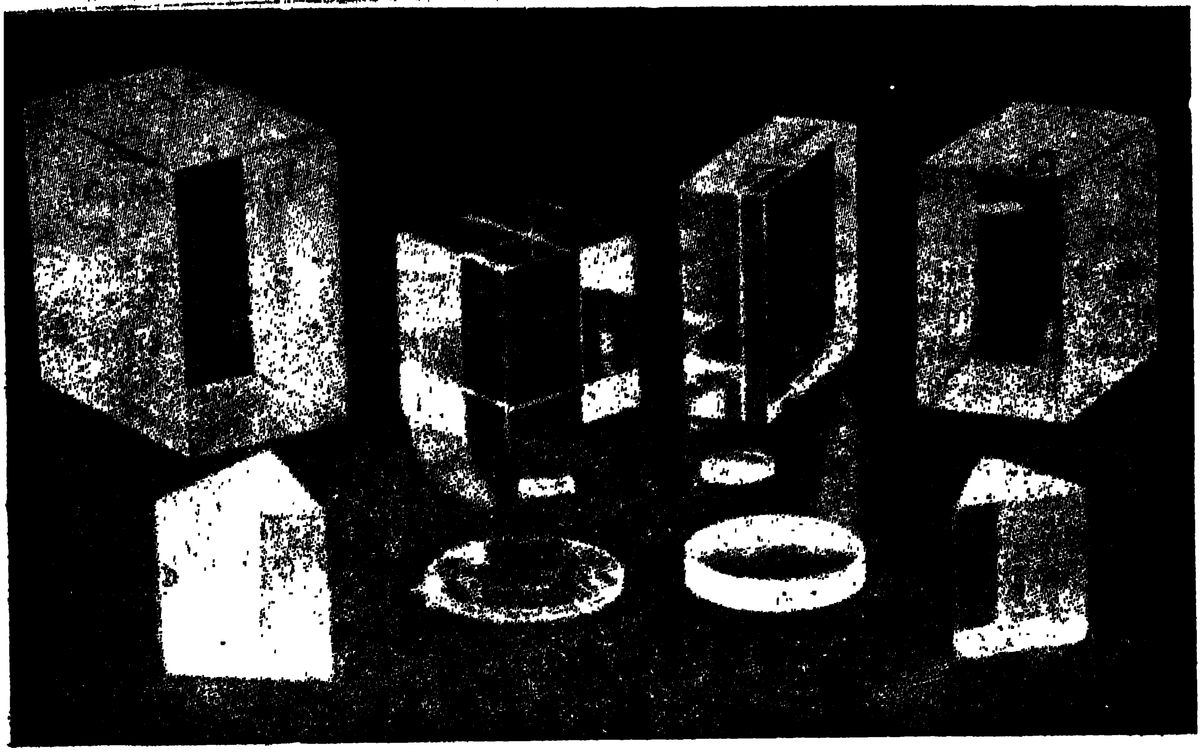

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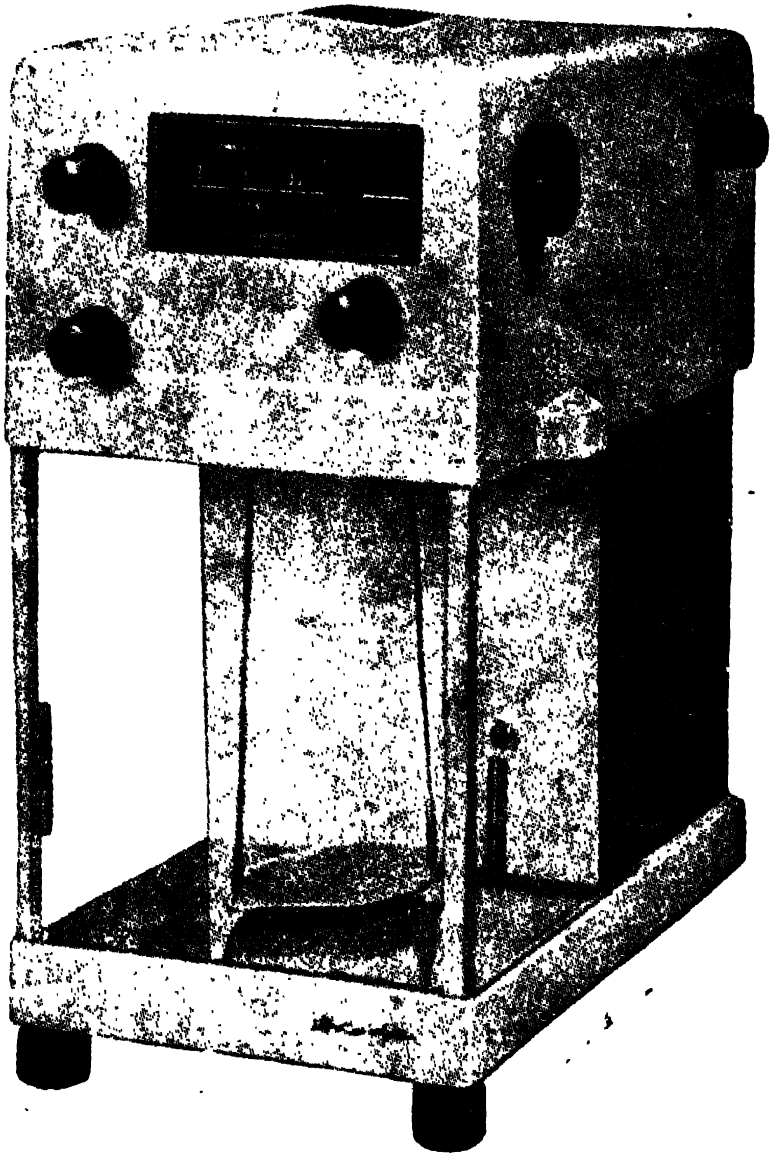

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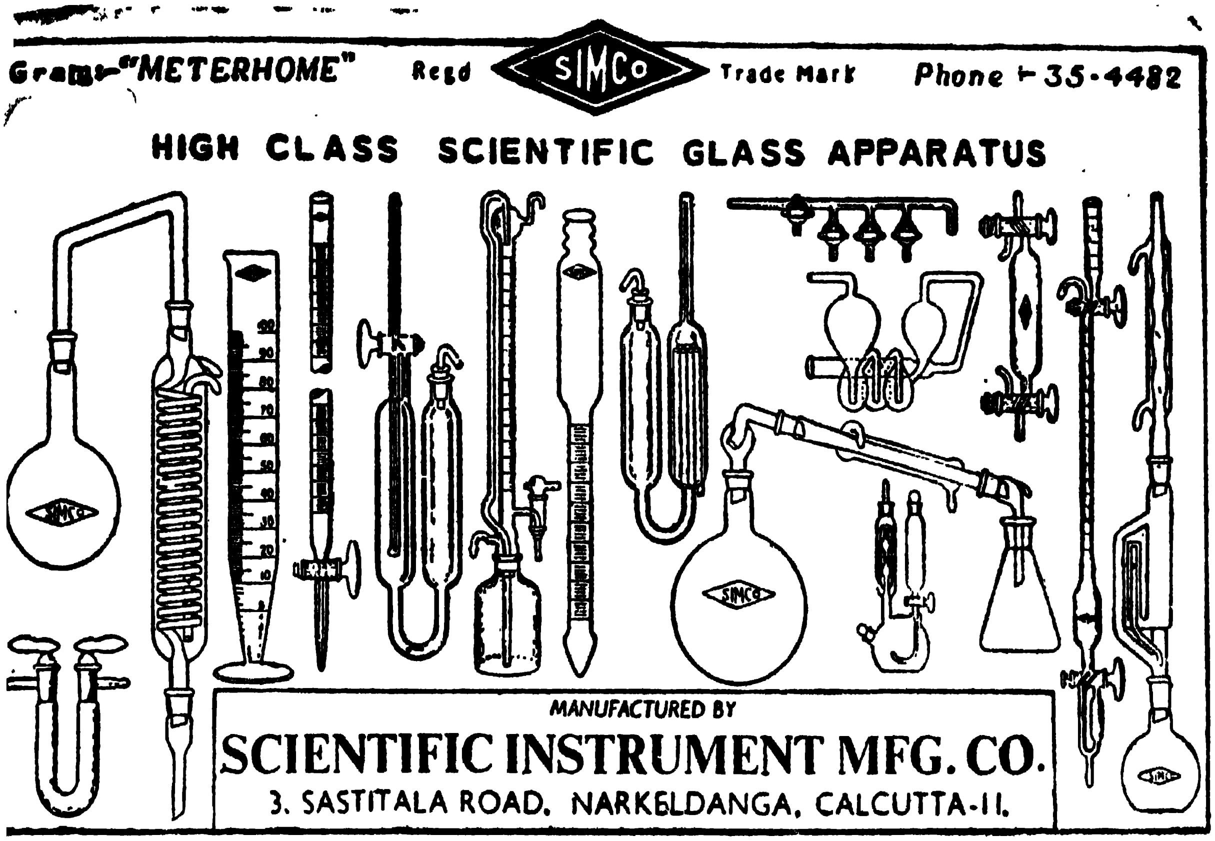

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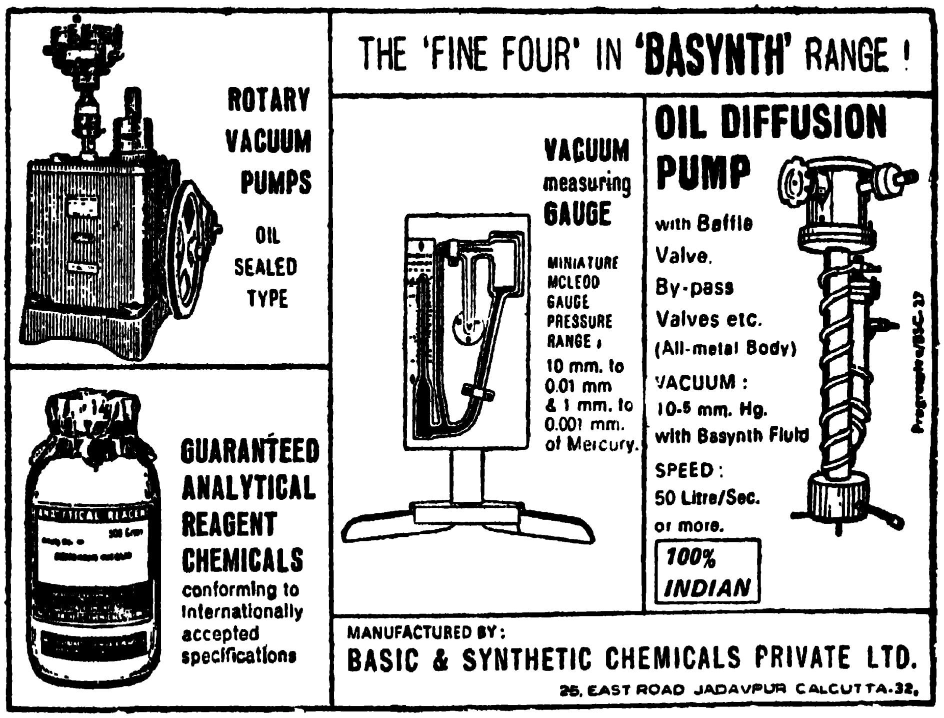

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ONE HUNDRED AND TWENTY-FIVE YEARS OF J. C. BOSE—*Santimay Chatterjee* 141

Debunking of Jagadis Chandra Bose—*Dibakar Sen* ... 142

Early Microwave Engineering: J. C. Bose's Physical Researches During 1895-1900—*B. Mitra* ... 149

NOTES AND NEWS 154

LETTERS TO THE EDITOR:

Nature of inhibition of TI-2, an inhibitor from *Streptomyces griseus* Cal. on trypsin and chymotrypsin—*Mina Mukherjee* 157

New variety of dye-reagents for the detection and identification of some organic compounds—*M. K. Dutt* 158

Effect of *Celosia orgentea* Linn. on root nodules and nitrogen contents of three legume crops—*S. M. Pandya, V. R. Dave* and *K. G. Vyas* (Miss) ... 161

Effect of vitamins on the regeneration of adventitious roots—*S. K. Mitra, R. S. Dhua, J. Biswas* and *N. Roychaudhuri* 163

Cytology of hybrids of the *Solanum nigrum* L. complex —*G. R. Rao* and *Anil Kumar* 164

Inheritance of leaflet shape in pigeon pea—*R. D. Ghatge* and *A. K. Kolhe* 165

Effect of sublethal dosages of insecticides on the population dynamics of pulse beetle, *Callosobruchus chinensis* L.—*N. Dutt* and *Debasis Ray* ... 167

Comparative pollen spectra of honey samples from West Dinajpur and Jalpaiguri Districts of West Bengal—*Pabitrananda Ganguly, Swati Gupta, Kashinath Bhattacharya* and *Sunirmal Chanda* ... 170

Effect of farm-yard manure (FYM) on response to potassium by maize—*B. Singh* and *B. L. Singh* 172

Effect of *Azolla* inoculation in checking the weeds under low-land rice—*S. Kannaiyan, M. Thangaraju* and *G. Oblisami* 174

Record of some new predators of *Tetranychus neocaledonicus* Andre (Acarina: Tetranychidae) from India—*Y. D. Pande* and *B. L. Sharma* ... 175

Leaf rust of *Cymbopogon jawarancusa*—*A. K. Dhar* and *K. Rekha* 176

SCIENCE ACADEMY MEDALS FOR YOUNG SCIENTISTS-1985

Instituted by the Indian National Science Academy in 1974 these medals are awarded annually in recognition of outstanding work of scientists below the age of 32 (as reckoned on 31st December preceding the year of award). Only those born on or after January 1, 1953 are eligible for consideration in 1985. The work done in India by the nominee will be taken into consideration for the award.

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SCIENCE & CULTURE

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ONE HUNDRED AND TWENTY-FIVE YEARS OF J. C. BOSE

SCIENCE museums, science clubs and a few science societies are celebrating the 125th anniversary of the birth of J. C. Bose this year. We join them in expressing our gratefulness and appreciation of that great son of India who introduced modern science in this country and single-handed, put India in the scientific map of the world.

How did he do it? While dedicating the Bose Institute he spoke, "Thirty two years ago, I chose the teaching of science as my vocation. It was held that by its very peculiar constitution, the Indian mind would always turn away from the study of nature to metasphical speculation. Even had the capacity for enquiry and accurate observation been assumed to be present. there were no opportunities for their employment; there were neither well-equipped laboratories nor skilled mechanicians. This was all too true. It is not for man to complain of circumstances, but bravely to accept, to confront and to dominate them; we belong to that race which has accomplished great things with simple means".

As if to justify his statement two young scientists rose to international eminence in the next seven years. They were Meghnad Saha in 1920 and S. N. Bose in 1924. Both of them had been J. C. Bose's students in the B. Sc. class. They were lecturers in the Calcutta Science College when the dedication lecture was given in 1917. Another maverick who was a few years junior to J. C. Bose started his research as a hobby at the Indian Association. He also proved his mettle very soon. C. V. Raman discovered his new radiation in 1928 which brought him the Nobel Award in 1930.

However these are isolated examples. One is forced to conclude that by and large the Indian mind is still drawn more towards philosophical abstractions than to a study of nature. Even after 80 years scientific temper has not grown among us. Science remains a separate citadel where many enter to earn a living, but go back home to the same set of highly unscientific values.

There is evidence of another kind of orthodoxy operative in professional circles of which J. C. Bose was a victim. But true to his nature (and in this lies the essence of his greatness) he struggled till recognition came. We should not lose sight of that twenty year struggle—it still remains an example and a lesson for all those who have conviction of ideas to lead them onwards.

In the same address J. C. Bose says; "In the persuit of my investigations I was unconsciously led into the border region of physics and physiology and was amazed to find boundary lines vanishing and points of contact between the realism of the Living and the Non-living".

He communicated his first research paper on this subject to the Royal Society, London in 1901. It was rejected. Undeterred, he published his book *The Living and the Non-living* in 1902 (Longman, Green & Co., London). He went on publishing his results in books, devised better and better instruments, took several trips to Europe to deliver demonstration lectures and finally convinced his European colleagues about the correctness of his results. It took him 20 years to do so and in 1920 he was elected a Fellow of the Royal Society. Patrick Geddes in his biography of Sir J. C. writes, "The difficulty among the orthodox, in science and in relegion, is the relation of the new truth to old theory". There have been many victims of such orthodox attitude. The most striking example, of course, was awarding Nobel Prize to Einstein 'not for his General Theory of Relativity'.

Any published scientific work is likely to be tested and assessed again and again. J. C. Bose has been put on trial time and again, praised and criticised. The process has not ended and now a new brand of psychological 'studies' have also been published. In this issue we publish an article 'Debunking of J. C. Bose' which summarises the nature of these studies published over the last 75 years. Another article—"Early Microwave Engineering: J. C. Bose's Physical Researches during 1895-1900"—describes J. C. Bose experiment in generating and detecting electromagnetic waves of wavelengths in the millimeter range—50 years before the microwave engineering came to win the second world war.

There has been uncritical admiration, just praise and even biased criticism of J. C. Bose. But this pioneer still largely remains a lone figure. There are aspects to be explored, evaluated and put into proper perspective, a century and a quarter has passed. The time seems to be ripe for a revaluation. □

Santimay Chatterjee

DEBUNKING OF JAGADIS CHANDRA BOSE

DIBAKAR SEN*

[*Editors' Note:* **When J. C. Bose was creating history by his investigations into the borderline areas of living and non-living, reactions were mixed. Dibakar Sen in this article presents some curious data and also attempts to pinpoint the motivations of the people who were and are still trying to debunk Bose].**

IT is sometimes seen that a certain scientist has achieved the pinnacle of success in a particular branch of science, but it is rare to see a scientist achieve such outstanding results in a number of branches simultaneously. Discussing J. C. Bose's researches in 14th April 1896, Lord Kelvin wrote: "I am literally filled with wonder and admiration for so much success in the novel and difficult problem which you have attacked". The journal *The Electrician* discussing J. C. Bose's researches in physics had forecast. "His sensitive detector of electro-magnetic radiation perfectly prompt in its self recovery, should serve to revolutionise the existing methods of wireless telegraphy". In 1920, *The Electrician* again assessing Bose's work said: "Dr. Bose's work on response of inorganic matter affords a striking illustration of the far-reaching character of the long and elaborate series of research which he has been carrying on for many years". The President of the Royal Society in a letter to J. C. Bose in 1914 wrote: "I was much impressed by the most ingenious and novel self-recording instruments whereby you are able to make plants automatically record their responses to electric and other stimulations. The means of physiological investigation thereby afforded is of much importance. Professor Leno of Taskent University, Russia said: "The great success of comparative electro physiology is indivisibly connected with your name. The translation of your works would be of the greatest help to Russian physologists". The femous Russian scientist Timiriazeff said : "A very remarkable of the application of exact physical methods to the physiology of the plant is afforded by the labours of the Indian savant whose very name indicates a new era in the development of science in general. His work must at once be acknowledged as a classic in the field of physiological research".

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*Bose Institute, Calcutta-700009.

The *Encyclopeadia Brittanica* evaluating J. C. Bose's research said, "His work was so much in advance of his time that the precise evaluation of it was not possible",

In the response to these tremendous achievments of J. C. Bose two trends can be observed in this country. As regards the first trend, Sajanikanta Das, editor of the *Sanibarer Chitti*, wrote 40 years ago, "ordinary people do not have a clear idea adout Jagadis Chandra's scientific achievements. They know he had something to do with the radio and the general opinion is that because he was an enslaved poor Indian he was not able to reap the full benefits of his discovery. Marconi had seized all the credit". It may be mentioned that distorted notions about Jagadis Chandra's investigations into the response of plants and inorganic matter also exist. What Sajanikanta had said is largely true even to-day.

The popular writings of scholars are the channels though which ordinary people derive their knowledge. Most of the popular literature on Jagadis Chandra and his researches appear to be based on limited historical knowledge and on an appeal to the emotions. One rarely sees concrete facts placed before the reader.

The second trend, though diverse in form, is, somehow or other to decry or malign Jagadis Chandra before the public. We have Bose's own reaction to this propaganda from a letter written on August 1929 to Professor Vines. Expressing regret, he said, "It is much easier to raise oneself from obscurity by criticising or appreciating the work of a man who is becoming well-known. The object of the propaganda is evidently to discredit my work, and as the Government grant is subject to the vote of the Delhi Assembly, it might serve to harm the Institute by the refusal of grant".

Jagadis Chandra, we all know began his research entirely by his own efforts. He encountered numerous obstacles and difficulties all along. Speaking of how he began his scientific work, he said, "What was my equipment and what was my laboratory ? There were practically no instrument and the size of my laboratory was a small room adout 20 ft. square with an attached bathroom". The idea of a cut in the governments' financial assistance to his Bose Institute, built with such effort was uppermost in his mind and perhaps the possibility of any other personal motive did not occur to him. But after the passage of so many years it is natural to ask if all this hostile propaganda was directed solely for the purpose of reducing government grants ? Or were there deeper reasons ? If one examines the hostile propaganda against J. C. Bose one can see in it a strange consistency and continuity. The motives for hostality may have been different. Apparently for certain foreign elements the very idea that Indians could advance in science on their own was intolerable. Hence their first objective was to mislead people about the work of Bose. The simplest way to do this was to debunk him as a scientist. The propaganda aimed to tell future generations of Indians as well as others that it was only with the blessings of the West that Science developed in India ; that there was no Indian contribution in this development ; that science is alien to Indian Culture.

One comes across but few distortions with respect to J. C. Bose's epoch making researches in physics. The reason may be that his pioneering work here was in agreement with contemporary Western research. Another reason may be that the Western powers appreciated the tremendous military, administrative and commercial significance of his researches in radio. He was even invited to stay and work in England. But hostile propaganda against him began the moment he started his historical investigations into the response of inorganic materials to stimuli, the transition of the non-living to the living. and his investigations on plants, when he began to demonstrate his originality. We mention here a few examples of such attempts to debunk him. In 1919, J. C. Bose had just invented the magnetic crescograph, which magnified plant growth a million times, and was investigating the effect of different stimuli on plant growth.

The *Daily News*, 19th May, 1919 published a piece with this title, "Drunkan Flowers".

"Discovery of Famous Indian", on 13th October, 1925 the *Popular Science Sifting* (Vol. LXIIX, No. 1774) reporting on J. C. Bose's Photosynthetic Bummler Recorder published : "Plants Think and Feel". "Recent discoveries by Sir Jagadis Chandra Bose, the distinguished Plant Psychologist (Sic !) of Calcutta".

Reporting on the same researches the *Northern Whig* on 21.8.1925 stated "Thyroid Gland on Plants". "Indian Doctors' Tests".

J. C. Bose had carried out some remarkable observations on the effect of heat on plants. It so happened that the tree with which he began his researches was situated in country-yard of a temple. According to custom every evening bells were rung. The paper the *Morning Post*, sidetracking the problem dealt with in the investigations, published the following on 9th November 1925—"Trees Reactions to Sound".

A few days later on 12th November the *Glasgow Herald* writes : "It has been found that plants do react to sound, and that, for example, a certain palm tree bends, earthwards, as if in obeisance when temple bells in the vicinity begin to ring. Sir Jagadis Chandra Bose……".

J. C. Bose had investigated the spontaneous pulsation of the plant desmodium gyrans and its electrical response. He had just invented his Plant Phytograph instrument. The *Westminister Gazatte* on 30th June, 1926 reported on these investigations : 'Heart Beats of Plants'.

"More emotional than human beings. The plant spoke and wrote its life's history with the leaves". On this topic the *Daily News* on 20th May, 1927 published a headline referring to J. C. Bose : "The Plant Psychologist (Sic !)".

On 22nd May 1927 and on 26 6. 1927 the *London Observer* headlined its concurrence with the above in a publication entitled "The personality of the Plants".

J. C. Bose in his investigations of the nervous mechanism of plants posed the question himself, "Are plants self-conscious" ? He discussed the subject and took it up also in a popular article, "Is the plant a Sentient Being," published in the *Century Magazine*, (Feb. 1929, Vol. 117, No. 4, U. K.). The famous Russian botanist Timiriazeff in his book *The Life of the Plant*, did not rule out the possibility that plants had sensations. But he also said that the only way to answer the question was through more plant physiological research. J. C. Bose's views were similar. At his time there was just not enough data on plant physiology to answer this question. Being the scrupulous scientists that he was, Bose confined himself to facts, which were known. He refused to give any premature answers.

Taking advantage of the situation, a certain Mr. Dastur gave a talk at the Sir Cowasjee Jahangir Hall in Bombay, debunking J. C. Bose's Plant researches, a report of which was published in a few papers.

For a long time Dr. J. C. Bose displayed great patience towards these detractors It was not possible to remain silent any more. He was forced to give his opinion on Mr. Dastur. He said, "The greatest scientists in the world have accepted my theory and I cannot condescend to enter into a controversy with a novice in science". It was published on 5th October, 1928 in the paper *The Englishman*. A few days later J. C. Bose issued another statement concerning these recent developments. He said "In answer to the misrepresentation that my work shows a proneness to mysticism. I can do no better than quote the following from a review of one of my recent works that appeared in the *New York Times*, the reviewer unlike many others, taking care to read through the book and state that, "It is impossible to ignore the relentless logic of his conclusion which are based upon the most modern methods of scientific laboratory procedure. There is not a trace of mysticism; but it does contain miracles a plenty—modern laboratory miracles".

It is to be noted that the well known scientist Molisch, Rector of Vieana University, reacting to these attempts to damage J. C. Bose's scientific reputation, sent a communication to the journal *Nature*, publised on 4th August, 1928, stating that he had for many years been acquainted with the researches of J. C. Bose, and that J. C. Bose had brought about a new phase in modern scientific plant physiological investigations.

Meanwhile, some Indians also were trying to prejudice their countrymen against J. C. Bose. An editorial in the *Forward* of 30th September, 1928 wrote about such elements; "It is a striking coincidence that at about the time when Sir J. C. Bose has returned to his native land, rich in honour, conscious of the triumphs he achieved abroad, some of his own countrymen should seek to assail his undisputed position·······." A number of his fellow countrymen began to criticise J. C. Bose, when his success had already been widely acclaimed, that Bose was after publicity. That is why he preferred to write about his scientific discoveries in English instead of in his mother tongue. In reply Jagadis Chandra said, "My discoveries, which have been accepted abroad recently, has been previously published in my mother language. But it is my misfortune that these writings were not able to establish themselves among the cultured elites of this country for a long time. Our native universities are such that they suspect the validity of any truth which does not carry a foreign hall mark. When the Pundits of Bengal spurn what has been discovered in their own country and expressed in their own language, it is futile to expect that foreign divers will come to salvage such valuables from what these pundits have dumped into our rivers'".

J. C. Bose gave his last rejoinder to his critics in 1928. After Sir J. C's death in 1937, Dr. D. M. Bose succeeded as the Director of the Bose Institute and continued till his retirement in 1967. The years 1928 to 1967 are curiously free from any adverse propaganda. But then it began again. In 1974 one Mr. Peter Tompkins came to Calcutta and presented the research workers of the Bose Institute with his book, *The Secret Life of Plants*. Though a book on plant psychology it contained nothing more than a few passing mentions to J. C. Bose. From the blurb one could gather that Mr. Tompkins was educated at Harvard College, Columbia University, has served as a war correspondent in Europe and Africa, was involved in intelligence work in Europe and his written a number of biographies and histories. The book formed the basis of further work by a number of people including one Mr. Walon Green.

In July 1976, the Bose Institute received a letter from the Regional Officer of the Central Board of Film Censors. Calcutta, asking permission to let a Mr. Walon Green film a part of "The Secret Life of Plants" at the Bose Institute, for which purpose, a copy of the film script was submitted with the letter. The film was based on Tompkins and Bird's book, *The Secret Life of Plants.*

Any scientist sanctioning such a film script puts his scientific reputation in jeopardy. The Bose Institute authorities could advise the Government that such a film should not be made.

On 14th March 1978 a Mr. Marcel Vogel arrived at Bose Institute. He expressed his appreciation of Bose's instruments and experiments done with them. He was thankful that he had come to the Bose Institute. He had already done some work on the lines of J. C. Bose's researches. He claimed that after much hard work and application, he had acquired knowledge of

Indian yoga and done some research on it. He had demonstrated experimentally that it was possible to increase considerably the growth rate of plants by yogic meditation. If necessary the growth rate could also be reduced. The present writer fixed some grass in J. C. Bose's famous Crescograph instrument, and asked Mr. Vogal to demonstrate his yogic powers. In the presence of many senior scientists Mr. Vogal ultimately confessed that the plant under experiment appeared to be stronger than his yogic powers. He said he would try, again the next day and left. He was, however, never seen again in the Bose Institute.

A few months later there was a repetition of the same kind of farce. On 22nd August 1978 a Dr. Novillo Pruli came to the Bose Institute, claiming that he was a devoted follower of J. C. Bose's plant physiological investigation. Working on the basis of Bose's researches he had, however, come to some new conclusions. He claimed that, if seeds from a plant are shown separately—some by men, some by women—those planted by women would grow more quickly and give better results than those shown by men.

Science To-day published from Bombay carried in the November 1978 issue an article—"The not-so-secret life of plants". The authors Arthur W. Glaston and Clifford C. Slayman, both from the University of Yale were established scientists. The authors clarified in the article that for some reasons an anti-science wave swept through the U. S. in the mid-sixties and during this spell books like *Secret life of plants* were written. The authors of these books invoked J. C. Bose to support their mystic and obscure view points. But that could not undo what J. C. Bose had achieved. Glaston and Slayman explained J. C. Bose's work giving many examples.

On the national scene fresh assessments of J. C. Bose have come out—***Alternative Science*** by Ashish Nandy of the Centre for the Study of Developing Societies, New Delhi (1982). Nandy observes that J. C. Bose's scientific achievements were fraudulent, his relation with Rabindranath Tagore deteriorated with the years, that he was jealous of the latter's Nobel award and that he suffered from a mother complex. It is difficult to follow Nandy's argument. It is obvious that he is totally ill-formed about the first two comments and we refrain from commenting on complexes. Ashish Nandy's other observations are that

(a) J. C. Bose left physics and switched over to botany because he was weak in mathematics and (b) also because physics research was capital intensive ; (c) he was a third-rate botanist.

Another article on "J. C. Bose and his Instruments" by Subir K. Sen of INSDOC appeared in *Science Reporter* in December 1983. Sen's logic goes as follows—"If Bose was a great inventor and experimentalist, he was no theoretician. He had never done mathematics...." Sen goes on—"This lacuna failed him in many of his interpretations of experimental results. He could not interpret his own result justifiably". At one stage he writes : "When he was doing his microwave researches, the physics of the day was not mature (Sic !) enough. When it became so, soon after, by the first and second decades of the twentieth century, Bose was not following it and lagged far behind the tremendous growth in physics". On another context Sen writes, "He did microwave analog physics half a century before any one could think of it". Sen's statements are contradictory his reporting of Bose's work is full of omissions. It is not possible in the limited space to indicate where Nandy, Sen and others have gone wrong. But these will reflect the nature of criticism that are still being published. ☐

EARLY MICROWAVE ENGINEERING: J. C. BOSE'S PHYSICAL RESEARCHES DURING 1895-1900

B. MITRA*

THE one single invention during the second World War which could be said to have turned the tide of the things, is the invention of the RADAR. Naturally, it was kept secret till the end of the war. Then gradually people came to know of the importance of the centimeter radio waves,— in their singular ability to take directed flight and to get reflected from obstacles in the path and appear as echo at the transmitting station.

The world was excited about this apparently new invention. In 1948, Prof. S. K. Mitra, the then Ghose Professor of Physics in the Calcutta University, delivered the eighth Acharya J. C. Bose memorial address at the Bose Institute, Calcutta. He discussed some works of Sir J. C. Bose done before the turn of the century and came to conclude that Jagadis Chandra Bose working nearly sixty years ago from then must be held as a pioneer of very short radio wave generation and transmission techniques. In this field of nascent science Bose contributed equally as, or even more than his European counterparts, known as the 'Hertzians', viz. Oliver Lodge, F. J. Trouton, Zehnder in Germany, Fleming, Righi, Lampa, Lebedew and Popoff. Marconi, being inspired by lectures of Righi entered the field and it was he who ultimately won the race for achieving radio communication. He however used meters-long waves rather than microwaves. Studies of microwaves receded into the background and remained eclipsed by the triumphal successes of inventions of radio-valves and ultimately of voice communication made possible by the discovery of the methods of modulating the continuous waves. Then with the invention of the RADAR came the unexpected emergence of brilliance from the shadows of obscurity. To quote K. L. Smith (Victorian Microwaves, Wireless World, Sept. 1979;—"Many Science and engineering students in higher education still make believe how modern and upto the minute their advanced courses in microwaves are···. It seems to come as a considerable shock to these students when it is pointed out that such technology was nearly all spelled out sufficiently early on for Queen Victoria to have had the possibility of seeing and inspecting the hardware". Pioneering works of J. C. Bose during 1894 1900 have been recognised by many and two consecutive articles by Ramsay, and Ramsay and Snook appeared in the IRE journal (May, 1957 ; Feb., 1958), which threw considerable light on the unusual brilliance of those investigations.

Maxwell's equations appeared in 1865 and they held the predictions 'that electric oscillations in a circuit produce electric waves in surrounding space, that these waves travel with the velocity of light and light itself is a train of electric waves of very short wavelength'. F. G. Fitzerald, in 1883 was already suggesting that Leyden jar discharges should emit Maxwellian radiation. Hertz, with extraordinary ingenuity produced the Hertzian Resonator detector and conclusively demonstrated that such waves were no theoretical marvel alone but they really existed. Hertz's apparatus was resonant at around 500 MHz. In the Bath meeting of the British Association in 1887-88, Sir Oliver Lodge demonstrated powerful high frequency waves in wires. At the Royal Institution, London, Lodge, in 1894 demonstrated the production of very short waves of frequency 4 GigaHz. (wave length around 7.5 cm or just above "S" band). We notice the earliest incorporation of circular waveguide in his apparatus and in effect, the cavity resonator. Building upon earlier experiments of S. A. Varley (1866), Onesti (1884) and Branley (1890), Lodge produced an efficient detector of these radiations. His Coherer, used loosely packed iron filings as a circuit element in series with a battery and a galvanometer. On receiving electromagnetic waves, this packet would show a decrease of resistance, showing an increase of galvanometer reading. The actual reason of this behaviour has been much debated upon and remained obscure.

---

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At about the same time in 1894, J. C. Bose started work on electromagnetic waves at the exotic Eastern city called Calcutta, in a make-shift laboratory room, at one corner of a college building. "It is to Bose we owe a considerable advancement in millimeter wave studies". Only Peter Lebedew and Lampa competed with Bose and this trio, unaided by each other, produced waves as short as 50 or 60 GHz (6 mm-5mm). We have reasons to believe that it was Bose who first succeeded in bringing down the wavelength of these short waves, to only 50 times the wavelengh of the limit attained in the infra red radiation.

Bose's apparatus for producing millimeter waves had many novel features. He used spherical oscillator, with fair amount of radiating power (he succeeded in sending a directed signal at a distance of more than a mile). He refined his spherical resonator by partly enclosing it in capacitive cups on each side. This increased the charge stored and hence, energy, by capacitive loading. He could reduce the damping and efficiency of his system must have been so raised as to produce many more cycles of oscillations per discharge. On the 1st of May, 1895, he read his first paper in the Asiatic Society of Bengal, titled 'On Polarisation of Electric Rays by Double Refracting Crystals'. He states,—"I have succeeded in obtaining polarisation effects with crystals of moderate size. This I was able to do by reducing the length of electric waves to about 5 mm or so."

The description of his oscillator is interesting.—"The coil, a small storage cell, and the key are enclosed in a tin-box······ In front of the box, there is an opening, through which the radiating tube projects". It is evident that he devised rectangular cavity resonator. His 'radiating-tube' was the world's first rectangular 'wave-guide' by which he could direct the millimeter long oscillations as a beam.

Oliver Lodge's arrangement for his cm-long waves was not very different. He invented the 'radiating-iris' and also resonant cavities. He invented flanged circular wave guide receiving apertures and called them 'copper-hats'.

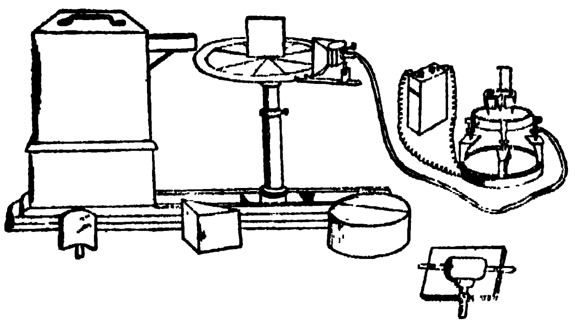

Fig. 1. Bose's complete electric ray apparatus demonstrated during the Friday Evening Discourse at the Royal Institution in 1897. His cavity resonator (rectangular box) and the rectangular wave guide are clearly seen. So also the pyramidal horn antenna (collecting funnel) placed before the detector. Wires lead to the galvanometer in series with the detector and the power cell. Scattered around the microwave bench are the prism, the polarising crystal holder, reflectors arrangement for the determination of the refractive index of glass, etc. The detector could rotate around the circular prism table in this "spectrometer"—like arrangement.

In Bose's first paper (Asiatic Society, 1895), he demonstrated his use of a long circular wave guide attached to his 'box'. He devised another form of antenna,—a shielded sulphur lens. He measured the refractive index of sulphur for his millimeter waves and gave the lens its required shape. It is evident that the modern shielded lens antenna was anticipated fifty years ago by Bose But by the time of his first Friday Evening Discourse at the Royal Institution (1897) his instrument had rectangular wave guide as well as a rectangular funnel-like device put before his detector, which is the evidence of the first use of rectangular microwave pyramidal horn antenna. He argued that the larger collecting area of a horn aperture would increase the energy incident on his detector. A microwave engineer designing his receiving aerial for satellite link reasons precisely in the same way. His complete apparatus, a microwave bench, had "all its different parts, including galvanometer, and all the accessories for reflection, refraction, polarisation and other experiments, (are) contained in a small case only 60 cm in length, 30 cm in height and 30 cm in breadth. This apparatus can be set up and various adjustments made in the course of few minutes" (Friday Evening Discourse, 1897).

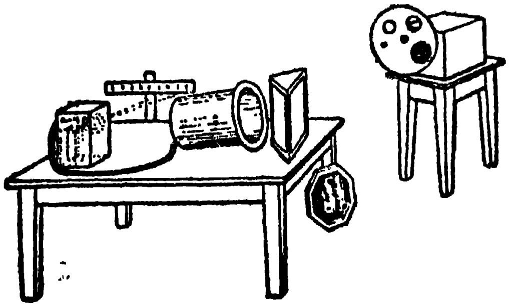

Fig. 2. Sir Oliver Lodge's arrangement of his centimeter wave apparatus. The radiating box or the cavity resonator along with his 'iris' or circular wave guide are clearly discernible On the left his 'copper hat' or flanged circular wave guide is seen.

Augusta Righi, in his book L'ottica delle Oscillazioni Elettriche, (1897) has described Righi's 2.6 cm micro-wave apparatus. In his oscillator, he used two spheres separated by a spark-gap in oil,—the gap length could be regulated. As the spark-gap was in oil, greater withstand voltage could be impressed and hence, more energy for sparks. After passage of spark-discharge through oil, the oil became sufficiently carbonized and then the damping was minimum. Righi's more important contribution was a novel resonator-detector, which was a tiny spark gap scratched on a thin strip of silver foil pasted on a glass slide.

The early detector of Bose was a somewhat curious, two-dimensional multiple spring-contact coherer, described in his very first paper, (Asiatic Society, May 1, 1895). 'It most likely consists of a space irradiated multicontact semi-conductor' (using natural oxide of iron springs) but may be 'with cohering action as well'. But the novelty of the thing has been described by Bose, as by adjusting pressure between the multiple contacts, the device was 'self decohering'. It did not have to be tapped every time it responded unlike the apparatus developed by Lodge. Equipped with this compact microwave bench Bose started experiments to prove the identical properties of electric waves and optical radiation, thus to become a recognized member of the international group of scientists known as the 'Hertzians'. He investigated polar diagrams, total internal reflection, refractive indices of odd refractors of waves of frequency in the 60 Gigahertz range.

He understood that the waves he generated were polarised. Hertz in his pioneering experiments proved that the Maxwellian waves generated in his linear oscillator were polarised waves. He used parabolic reflectors as antennae and crossing the focal lines of the two he demonstrated polarisation. He also used large sized (because his waves were large, the smallest that he produced being 66 cms long) wire gratings as polariser and analyser. Bose also made gratings of fine wires, fitted them in front of his transmitter and receiver's cylindrical antennae ('radiating tube'). He could very easily rotate them and in fact had all the requisite motions to establish polarisation angles. 'He must have understood the effect of wire gratings placed parallel, perpendicular and in practice in any angle, to the E-vector of the 60 GHz beam of radiation'. A no mean achievement. The work of establishing the polarizing and birefringence properties of ordinary crystals (beryl, apatite, nemalite, barytes, rock-salt, iceland-spar) was completed in 1894 and published next year. In 1895 he found the polarizing effect of serpentine, Satin spar, black tourmaline and nemalite. He states, "with fibrous varieties of crystals I found the vibration, as a rule, more easily transmitted perpendicular to the length of the fibres". In the same paper, which constituted one of those he sent to Lord Rayleigh at Cambridge, and which was promptly published by the Electrician (Dec., 1895), he describes the polarising property of vegetable fibres, including jute fibres. He performed experiments to establish the rotation of plane of polarisation by twisted jute cells. It has been pointed out by Ramsay and Snook in their article "Microwave Model Crystallography" (IRE, May, 1957), that Bose was the pioneer of the technique of analogue crystallography, which we hold to be so very modern scientific method. To quote from Bose (Proc. Roy. Soc., 1898),—"In order to *imitate* the rotation produced by liquids like sugar solutions, *I made small elements or "molecules"* of twisted jute, of two varieties, one kind being twisted to the right (positive) and the other twisted to the left (negative). I now interposed a number of, say, the positive variety, end to end, between the crossed polariser and analyser, this produced a restoration of the field. The same was the case with the negative variety. I now mixed equal numbers of two varieties, and there was now no restoration of the field, the rotation produced by one variety being counteracted by the opposite rotation produced by the other" (italics author's).

Methods of Analogue Crystallography can be briefly described as following. In an actual lattice of a crystal the atoms are arranged in a regular pattern, X-rays of wavelength comparable with lattice dimensions can be made to get scattered from actual atoms and the scattered beam register a regular diffraction pattern on the photographic film. Techniques have been developed to construct the actual lattice pattern from such X-ray diffraction photograph. This is X-ray crystallography. In analogue crystallography we 'make' small hard metal spheres and arrange them in the already conjectured three dimension lattice pattern to imitate a crystal and replace X-rays by many times longer microwaves. From the macroscopic scattering pattern obtained with microwaves we can get confirmation of our ideas of actual lattice pattern, which is so very submicroscopic. When J. C. Bose "made" imitation "molecules" and arranged them to imitate the 'dextro' and 'laevu'—rotatory substances and used millimeter waves to have rotation of plane of polarisation by the imitated molecules, he clearly anticipated the modern analogue crystallography technique.

In his Friday Evening Discourse of 1897 he demonstrated a few more unconventional polarisers of electric waves, viz, a railway 'Bradshaw', interleaved with tin foils and strands of human hair,—the darker hair being better polariser than the blond.

Bose did extensive research on behaviour of the detectors of electric waves. The earliest detector, the Branley-Lodge "coherer" was first improved upon by the use of a multispring contact device. By adjusting pressure between the contact points "the resistance offered by this portion of the circuit can, therefore, be gradually varied···. The resistance of the receiving circuit is thus almost entirely concentrated at the sensitive contact-surface···" ("On polarisation of electric rays, etc.", Asiatic Soc. Bengal, May 1895). He made important contributions to the elucidation of coherer action and he proved beyond doubt that Lodge's theory of micro-welding of the contacts on absorption of radiation was not tenable ; the name 'coherer', derived from the idea of coherence of contacts was rather wrongly coined. Bose's detector later took the form of a single metal point contact on a metal plate. He showed that by properly adjusting the pressure of this contact, by selection of proper metal and having a proper e. m. f. a self-decohering effect could be obtained.

To obtain this 'self recovery' he experimented with point contacts made of nearly every material. In the process, he found that the materials for the purpose could be classified into two groups, the positive or P-type of which the conductivity of the contact point increased on absorption of radiation and negative or N-type, of which the conductivity diminished. Sometime in the same material,—"Pressure and E. M. F.···also modify the reaction···a freshly made and very delicately adjusted coherer subjected to slight pressure and small E. M. F. showed an increase of resistance by the action of radiation······ The coherer continued to exhibit this effect for some time, then it relapsed into the more stable condition in which a diminution of resistance is produced······" (Proc. Roy. Soc., April, 1899). Although some of his results could be attributed to the formation of oxide layers on the metals transforming them into P-type and N-type semiconductors, his work with the contacts of alkali metals, dipped in kerosene oil can hardly be understood as such. Professor S. D. Chatterjee writes (The Oracle, 1982) "The Nobel-Prize winner Sir Neville F. Mott, Cavendish Professor of Physics, Cambridge University, once remarked to the (present) writer that J. C. Bose was at least sixty years ahead of his time." "In fact, he had anticipated the existence of P-type and N-type semiconductors".

It was of course not possible for him, in the period 1897-99, to spell out a correct theory of semiconducting behaviour because the role of quasi-free electrons in modifying electrical conductivity in crystal was not clearly known before Madelung and Born's theory of ionic crystals took shape in 1918-23. The electron, in 1897, was itself a newly discovered entity. Bose had an incomplete idea, that somehow the "···observed variation of conductivity produced by radiation is not due to coherence, but to certain molecular changes of an allotropic nature" on the surface of the material (On Electric *Touch*, etc., Proc. Roy. Soc. Feb. 1900). On his long and persistent inquiry into detector behaviour he discovered at least two phenomena which has filled the later scientists with surprise and admiration.

While working with his 'single point contact' receiver of short electric waves, ("···a sharp point of iron, pressing against a convex iron surface, the pressure being capable of very delicate adjustment by means of a micrometer") he found that "Electric conduction in metallic particles sensitive to electric radiation does not obey Ohm's Law. The conductivity is not constant and independent of the E. M. F. and varies with it···. The conductivity increases *continuously* with the increasing E. M. F. The variation of conductivity in the lower portion of the curve is small, but increases with great repidity in the upper portion. In the negative class of substance the characteristic curve is convex to the axis of the current" (On the similarity of conductivity of metallic particles etc., British Assn., Glasgow Sept. 1901). This is exactly the characteristic curve of a point contact *rectifier*. Pierce, in his book, Principles of Wireless Telegraphy (lst Ed. 1910) has given exactly the same characteristics, what he calls the essentials of *rectification*, according to an article by H. Brandes, (Electrotechnische Zeitschrift, 27, 1906). George Pierce has described the so called rising and falling characteristics of a rectifier, when behaving in the field of varying electromotive force,—again recognising this as the work of Brandes done in 1906. But we find that the same characteristics were present in Bose's British Association paper of 1901. It is rather unfortunate that Pierce chose to ignore Bose's work to describe Brandes as the discoverer of rectifier characteristics. Pierce again observes that Prof. D. J. Hughes, the inventor of telephone receiver, was actually producing and receiving electric waves, by a detector made of carbon pencil touching a steel needle, where pressure could be varied. Fahie's letter in *The Electrician*, in 1899 confirms this. But it is not known whether Hughes was aware of the rectification property, of which Bose certainly was.

In his search for self recovering detectors, Bose invented a galena crystal receiver of millimeter waves. He found that it was sensitive to both electric waves and radiations from infra-red to ultra-violet, through the visible part of the spectrum. In his second (1901) Friday Evening Discourse at the Royal Institution, he said "I have been able to construct an artificial retina constructed of galena. …Indeed the most striking peculiarity of this eye is that it can see lights not only some way beyond the violet, but also in regions far below the infrared, in the invisible regions of electric radiation. It is in fact a *Tejometer* (Sanskrit *Tej*—radiation), or universal radiometer".

Pearson and Brattain, in their report "History of Semiconductor Research" (Proc. IRE, 1954) give priority to Bose for the use of a semiconducting crystal as detector of radio waves. Pierce, in his otherwise admirable book states that General H. H. Dunwoody invented the first crystal-detector when he described his carborundum receiver in 1906. But clearly Pierce is wrong because Bose had already described his galena detector in 1901. As a matter of fact, he invented the device much earlier. It is possible that he came across the work of F. Braun, who did experiments with inorganic crystals of lead and iron compounds in 1870's and found that Ohm's Law does not hold for varying electromotive force across ohmic contacts in such crystals, in fact the V-I curve is non·

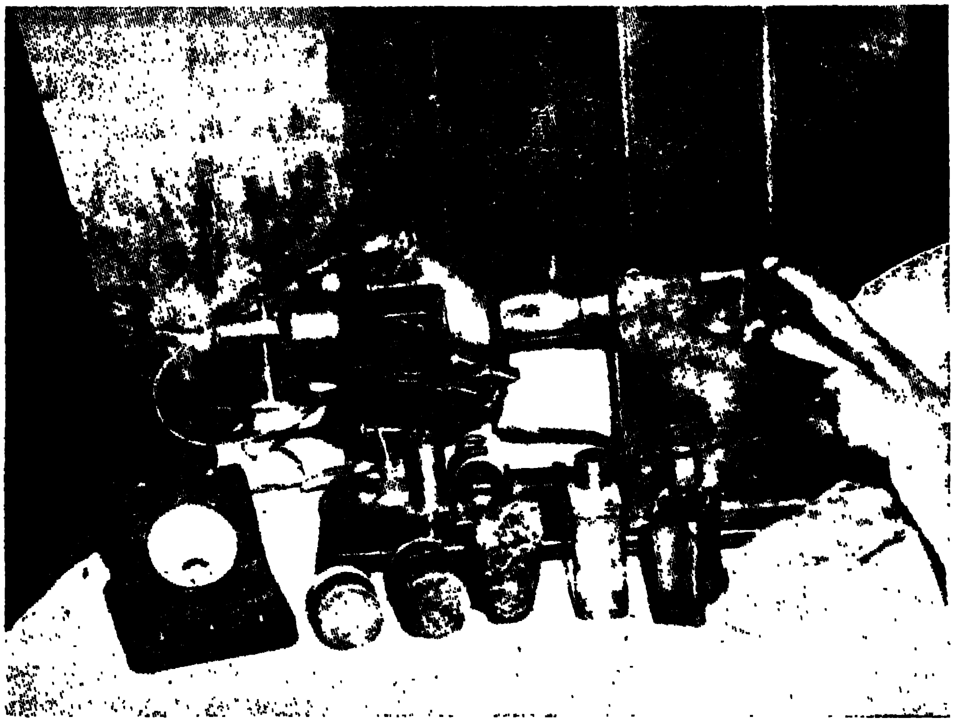

Fig. 3. A photograph of the microwave bench of J. C. Bose. The cavity resonator transmitter is at the right, along with the circular wave guide to direct the beam. The receiver is at the left at the end of the circular wave guide ended with a conical horn. Wire gratings are fitted at the entrances of the tubes both at the transmitter side and the receiving side. The tubes could rotate about their exes and hence the gratings make any angle with each other, thus allowing easy determination of the polarisation angles perpendicular to the E-vector of the waves. Arranged before the apparatus are his imitation molecules representing the left and right handed ones of the sugar molecules made of jute, and various absorbers and packs of fibre to demonstrate their polarising property.

linear. While Bose appreciated from his own work that the non-linear nature of such curve was essential for detection of electric waves, he substituted galena (a lead sulphide crystal, also studied by Braun) as one surface for his metal-metal point contact.

Whatever may be the case, with the invention of the sensitive point contact on galena (and selenium) he must have invented the first photoconducting cell as well as a semiconductor rectifier rolled into one. Nearly all the text books on Electronics and Infra Red Spectroscopy refer to his having invented the first photoconducting cell, none refers to the cell's equal sensitiveness to millimeter waves. This is the only invention among the scores of others, of which he took patent rights, both in England and in the U. S. A., at the insistence, respectively, of Sister Nivedita and Mrs. Sarah Bull (Sister Dheera Mata, the name given by the Ramakrishna Order). The American Patent was applied for in 1901, and granted in 1905, bearing US Pat. No. 755840 ; which still was much before General Dunwoody's obtaining patent for his carborundum detector having US Pat. No. 837616. This was applied for in March 1906 and granted in December of the same year.

One would now be inclined to look into the priority of radio communication, albeit by microwaves. Microwaves have proved themselves to be a more versatile communication medium. Bose started work on electromagnetic waves after his 36th birthday, i.e. after the 30th of November 1894. Sometime in early 1895, he arranged a demonstration of his apparatus in the Presidency College, Calcutta. He succeeded in sending signals at a distance of about 70 feet, beyond two intervening walls. More interestingly, he performed probably the world's first radio-dynamical work, automatically from a distance, with his 5 mm waves as they operated relays to automatically blow up gun powder and to ring a bell. Sometime later he gave a public demonstration at the Calcutta Town Hall. Many Calcutta newspapers carried the news. Only another record exists, of automatic radio-dynamic work performed in 1895 December, that by Popoff, in Russia, who arranged to ring a bell whenever his detector detected atmospheric electrical discharge. But this cannot be compared with the purposeful automatic work obtained by controlled stimulation as was arranged by Bose. In Fahie's "History of Wireless Telegraphy" a letter from Popoff written in December 1895 has been published in which he says, "I entertain the hope that when my apparatus is perfected it will be applicable to the transmission of signals to a distance by means of rapid electric vibrations—when in fact a sufficiently powerful generator of this vibration is discovered".

Bose devised his sensitive galena detector in 1896 and a report appearing in the Daily Chronicle (London) 29th November, 1896, runs thus—"The inventor (Bose) has transmitted signals to a distance of nearly a mile and herein lies the first and obvious and exceedingly valuable application of this new theoretical marvel. It is telegraphy without any kind of intervening conductor". Bose had sufficient power for his transmitter. He was aware, that "For experimental investigations it is also necessary to have narrow pencil of electric radiation and this is very difficult to obtain, unless waves of very short wavelength are used. ···All these drawbacks were ultimately removed by making suitable radiators emitting very short waves" (Friday Evening Discourse, 1897). Thus all the engineering associated with microwave communication were known to him and were incorporated in his instrument. Marconi used longer waves closer to the present day short wave band. For his first experiments Marconi used parabolic antennae after Hertz and used Branley-Lodge coherer as detector. The relative success of Marconi has been descrided by Pierce, thus···"we see that the gain in distance came about primarily through the fact that with this apparatus his circuits were placed vertical rather than horizontal, and also through the use of longer waves and more energy and larger radiating and receiving antennae···" (Principles of Wireless Telegraphy, Pierce). Marconi applied for patent rights for his instrument in England in May, 1896 but had to submit the application again in March 2, 1897.

"We may, without controversy, say that while J. C. Bose was the pioneer of microwave (millimeter wave) communication, Marconi's work ushered in the days of wireless telegraphy which more conveniently used short waves of a few meters. ☐

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NOTES & NEWS

Eminent Indian Physicists on Exhibition (BITM)

Birla Industrial and Technological Museum, Calcutta, while celebrating its Silver Jubilee (May 1983—May 1984) mounted an exhibition (April 7—May 6, 1984) on the lives and works of the three Calcutta scientists, viz., the late Sir J. C. Bose (125th anniversary) and Prof. M. N. Saha and S. N. Bose on their 90th birthday. The inaugural meeting was held in the afternoon of 7th April under the Chairmanship of Dr. B. D. Nagchaudhuri and the chief guest speaker was Prof. D. S. Kothari (Ex-Chairman of UGC) one of the earliest surviving students of the late Prof. Saha.

The whole exhibition displayed sequentially the important events in their lives through photographs, documents and working demonstrations of some experiments relating to their scientific works and other various activities, including their hobbies, were also brought to the attention of the visitors mainly from Calcutta and outside areas in the State of West Bengal.

During the period of the exhibition three separate lectures on the individual scientists were delivered in Bengali by the three different speakers as follows :

Life and Works of Prof. S. N. Bose by Dr. Partha Ghosh,

Life and Works of Prof. M. N. Saha by Shri S. N. Sen,

Life and Works of Sir J. C. Bose by Shri Dibakar Sen.

These lectures were rather illuminating and well received by the audience.

The exhibition was visited by large crowds everyday, specially, large number of school students from outside Calcutta.

The exhibition had been possible and successful through the co-operation of many individuals and institutions within the country and abroad. Special mention may be made of the Imperial College of Science & Technology (London), Royal Institution (London), The Royal Society (London) and the High Commission of India, Dhaka (Bangladesh).

On this occasion, a booklet giving the Chronological Biographies (With particular reference to their great scientific events) of all the three scientists was brought out. ☐

S. K. Guha

Seminar on Teaching Plant Physiology at Undergraduate and Postgraduate Levels

For the first time in India, a National Seminar on "Teaching Plant Physiology at Undergraduate and Postgraduate Levels : Problems and Prospects" was organised by Plant Physiology Forum, Calcutta at Sabitri Girls' College on 30. 4. 84. A large number of University and College teachers from West Bengal and other states of India and Bangladesh participated in the Seminar.

Prof. S. P. Sen, President of the Forum in his key note address, emphasised the need of offering courses in physical sciences for plant physiology students. He regretted that plant physiology which is so important for plant sciences and agriculture has received very little attention from the educationists and education planners. He stressed the importance of innovative approaches in the teaching of plant physiology. Prof. B. B. Biswas suggested the introduction of plant physiology as a full subject for the M. Sc. courses, and emphasised the need of a unified syllabus for different Indian Universities. Prof. C. P. Malik thought that refresher courses should be introduced as far as possible and the structure and function of a plant should be dealt with simultaneously from the very beginning. Prof. P. C. Tripathy discussed the teacher factor in plant physiology teaching. Prof. S. N. Mathur regretted that the recommendations of Prof. K. V. Thimann as in the late fifties for improving teaching and research of plant physiology in Indian Universities were never seriously considered. He stressed on increasing job opportunities for plant physiology students. Other aspects discussed include : use of instrumentation as an aid to teaching plant physiology, the methods of teaching plant physiology as an interdisciplinary science, limitations for the development of courses, lack of facilities and time devoted to teaching, problems encountered in conducting laboratory courses, etc. A large number of participants felt the necessity of finding ways and means for continuous self-assessment and refresher courses for the teachers for improving the quality of teaching plant physiology. A set of limitations and recommendations were made in the concluding session.

Limitations : (1) At the undergraduate level and sometimes at the postgraduate levels also, Plant Physiology is taught mostly in a descriptive manner and the approach is not analytical. Teaching is examination-oriented and the questions usually set on such that it does not elicit thinking on the part of the candidates.

(2) Emphasis is given more on imparting information rather than basic concepts.

(3) There is a lack of unified syllabi/unified standards of teaching Plant Physiology throughout the country.

(4) Imbalanced treatment of the different aspects of Botany at the undergraduate level, eg., structural and functional aspects of Plant parts/organelles are not taught simultaneously and more emphasis is given on structural (morphology, anatomy) than functional aspects (physiology). Plant Physiology should be taught as an interdisciplinary science.

(5) From Higher Secondary to undergradute level, hardly 10 percent marks are allotted to Plant Physiology. Time allotment for teaching of this subject is even less.

(6) Many student do not have the proper background in physical science to undertake courses in Plant Physiology or comprehend the concepts adequately.

(7) There is indeed a dearth of motivated teachers who can inspire the students.

(8) Library facilities are miserable in most cases.

(9) There is paucity of good text books/supplementary reading materials. Most of the foreign text books and even some text books by Indian authors do not have any reference to Indian works/problems or native examples.

(10) Inadequate laboratory facilities for practical classes can not generate sufficient interest amongst students and the over-all conception is usually not clear.

Recommendations : (1) India, being basically an agricultural country, Plant Physiology should develop here as a major science and it deserves adequate support from Government and other agencies. Planners of science education should give more thought to the development of teaching Plant Physiology in India while fixing priorities.

(2) The time has come for Plant Physiology to be taught as a separate subject at the M. Sc. or M. Phil. level. Where this is not

feasible, it may be taught as a special paper in M. Sc. (Botany). In either case, the Plant Physiology course may be subdivided into modular courses comprising of core subjects and elective subjects. The core subjects should be uniform in all Indian Universities and should try to impart a balanced view of Plant Physiology as a whole. Combination of elective courses may be different at different universities, depending upon the expertise or excellence of a particular centre/institution.

(3) Students taking Plant Physiology as special paper should preferably have physics, mathematics and chemistry as subsidiary subjects at the undergraduate level Physico-chemical aspects of plant life and analytical techniques including instrumentation should be discussed at the special paper level. Elementary physical science courses combining physics, chemistry and mathematics can also be introduced at the postgraduate level to make up for the deficiencies at present. Ph. D. students may be allowed to attend courses in Physical Sciences at the Universities.

(4) The structural and functional aspects of plants should be taught simultaneously. The subject will then be more meaningful and attractive to the students. This will also reduce the time required for teaching them separately.

(5) To avoid duplication and overlapping, the course should be divided clearly as far as practicable, into three levels : (a) upto Higher Secondary, (b) undergraduate (B.Sc.) and (c) postgraduate (M.Sc.).

(6) The teaching programme can be formulated/modified according to national or even regional needs. The students should have an awareness of a lively science which has much to contribute to the development of the country. At the postgraduate level, after studying different aspects of Plant Physiology separately, attempts should be made for teaching the plant as whole. For this, a case study of a regionally important plant (viz. rice, jute, wheat, maize, cotton, tobacco, sugarcane, potato, pulses, etc.) may be considered in all its aspects (germination, growth and development, flowering, maturation, yield potential, interaction to environment, etc.).

(7) Innovative teaching/evaluation system should be evolved so that students are made to think and study by themselves rather than feeding all the available information to them. To make this effective, sufficient reading material should be provided to students.

(8) About 15% teaching time should be allotted to the teaching of Plant Physiology at the subsidiary (submajor) and honours (major) levels.

(9) More emphasis should be given to practical classes. Each student should be made to work in the laboratory at least in small groups, if not individually. Adequate funds for proper laboratory facilities should be provided. Specialised experiments which can not be performed in class rooms for lack of adequate facilities can be demonstrated by taking the students to local research institutes/ universities.

(10) Indian experts in different aspects of Plant Physiology should be invited to write jointly edited text books giving proper emphasis to Indian contributions thus, inspiring students to take up Plant Physiology for higher studies.

(11) Laboratory manuals should be prepared by experts/teachers at the All-India level for improvement of laboratory courses throughout the country at the undergraduate and postgraduate (general paper and special paper) levels.

(12) From the undergraduate level itself, sufficient time must be allotted for students' seminar/discussions/ colloqua / quiz / objective tests/visit to local agricultural fields/visit to research institutes, universities, etc

(13) To improve the quality of teaching, refresher courses/workshops for the teachers should be organized at regular intervals. There should be provision for short-time exchange of teachers between institutions to teach specialised courses under the auspices of UGC or similar organizations.

(14) A system should be evolved to have feed-back from the students to the teachers through teacher's evaluation/questionnaire etc.

(15) More job opportunities for Plant Physiologists should be created to attract good students. The State Departments of Agriculture and scheduled banks and industries can employ Plant Physiologists who are equivalent to Agriculture graduates in most cases. Their participation in the developmental programmes of the country is likely to benefit the country as a whole. □

S. P. Sen

LETTERS TO THE EDITOR

Nature of inhibition of TI-2, an inhibitor from *Streptomyces griseus* Cal. on trypsin and chymotrypsin

So far many trypsin-chymotrypsin protein inhibitors have been reported from the plants[1-3] which are double headed in nature. Previously two protein trypsin inhibitors and two peptide trypsin inhibitors have been reported from *Streptomyces griseus* Cal[4-6]. One of the protein inhibitors, named TI-2, has been purified[4]. It has been found that TI-2 inhibits both trypsin and chymotrypsin. In the present investigation, the nature of inhibition against both the enzymes has been studied.

The inhibitor (TI-2) was isolated from the culture filtrate of *S. griseus* following the previous method of acid-precipitation, heating, ammonium sulphate precipitation and gel filtration[4]. Inhibitor assay was done following the earlier method of Mukherjee and Thangamani[4]. One unit of trypsin and chymotrypsin is defined as that amount which liberated TCA-soluble fragments having OD_{280} by 0.001/minute and one unit of inhibitor as that amount which decreased OD_{280} by 0.001/minute from the enzyme control.

The nature of inhibition was determined by the method of Lineweaver and Burk[7]. The results (data not shown here) indicated that the inhibition against both trypsin and chymotrypsin was non-competitive type, i.e. inhibitor had no effect on K_m, whereas V_{max} appreciably decreased with increasing concentration of inhibitor.

To find out the effect of TI-2 concentration on trypsin and chymotrypsin fixed amount of trypsin (40 U) and chymotrypsin (40 U) were incubated at 30°C for 30 min with different amount of TI-2. The residual enzyme activity was measured. Fig. 1 shows that with increased concentration of inhibitor decrease of trypsin activity was taken place proportionally. But it is also noticed that against chymotrypsin 100% inhibition has not been obtained. The maximum inhibition is 20%.

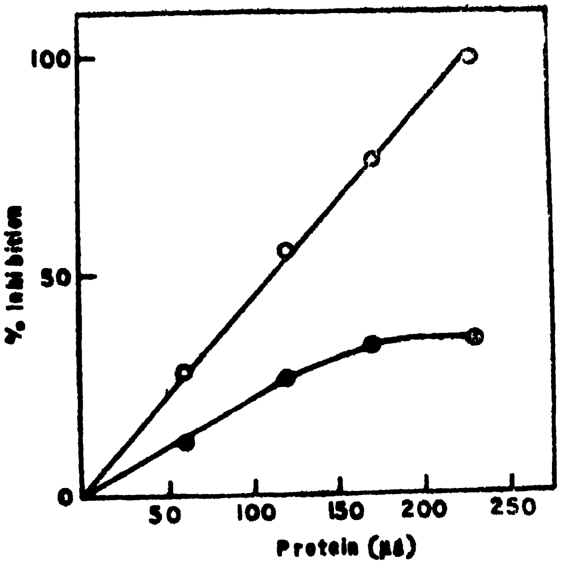

Fig. 1. Effect of different concentration of inhibitor on trypsin and chymotrypsin activity [(-○-) trypsin activity, (-●-) chymotrypsin activity].

To find out whether C-terminal is important for the inhibitory property, the inhibitor was incubated with carboxypeptidase A at pH 8.0 in 0.005 M phosphate buffer for different periods of time. The inhibitory activity against trypsin was found to be lost within 30 min of incubation but for losing complete chymotrypsin activity minimum 4 h incubation is necessary From the above results, seems that C-terminal of the inhibitor is very important for the inhibitory activity of the protein but it is not the same C-terminal responsible for inhibiting both the enzymes.

Complex formation between TI-2 and trypsin was determined by gel chromatography on Sephadex G-200 column (2 cm × 150 cm). The column was equilibrated with 50 mM phosphate buffer, pH 7.0. In each experiment, the components were applied to the column in a total volume of 1 ml in 50 mM phosphate buffer (pH 7.0). To obtain the trypsin-inhibitor complex, 600 µg of protein of bovine trypsin was incubated with 600 µg of protein of inhibitor TI-2 at 30°C for 30 min and the mixture was applied to the column. The fractions were assayed for protein content and trypsin and chymotrypsin inhibitory activity. In separate experiments inhibitor TI-2 (600 µg/protein), bovine trypsin (600 µg protein) were passed through the column to determine the elution pattern. The results on complex formation between inhibitor and the enzymes are depicted in Fig. 2. The first peak of the figure (a) represents the complex, the second small one is trypsin and the third one is inhibitor peak. The pooled fractions of the first peak after lyophilization was tested against trypsin and chymotrypsin. The complex has got no anti-tryptic activity but 60% of the original chymotrypsin activity was there. The results indicate that TI-2 must have two bindding site for trypsin and chymotrypsin.

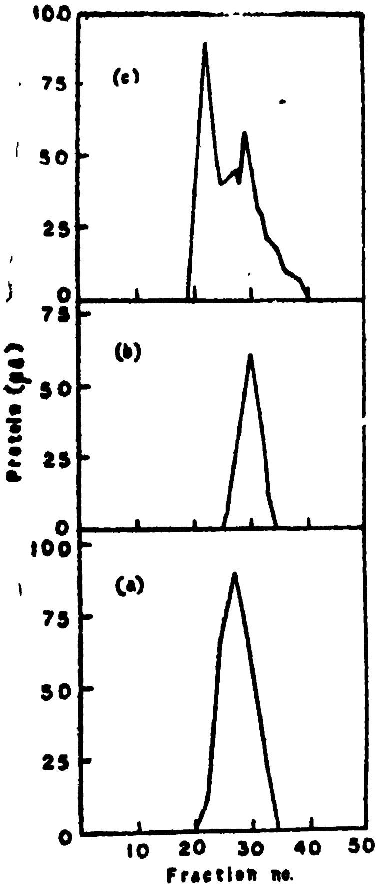

Fig. 2. Complex formation between inhibitor TI-2—trypsin on a Sephadex G-200 column (2 cm × 150 cm). [The column was equilibrated with 50 mM phosphate buffer, pH 7.0 (a) trypsin inhibitor complex, (b) try. sin, (c) inhibitor 1 ml fractions were collected].

Loss of 40% anti-chymotrypsin activity may either be due to steric hindrance caused by trypsin which was already bound to TI-2 or the binding of chymotrypsin—TI-2 was not tight. By isolating trypsin-inhibitor complex, it also has been proved that the inhibitor binds directly to the enzyme molecule. Therefore, the inhibition of trypsin by TI-2 was due to formation of the inactive complex rather than proteolytic inactivation.

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New variety of dye-reagents for the detection and identification of some organic compounds

Thionine and brilliant cresyl blue are basic dyes of the thiazine and oxazine groups respectively. Aqueous solutions of these dyes can be decolourised with N H_2SO_4 and sodium sulphide. These decolourised dye-reagents can then be used to detect both solid and liquid organic compounds[1,2]. In an effort to decolourise these dyes with $HClO_4$ plus conc. H_2SO_4, the present author has developed a pale green reagent with thionine and a pale brown reagent with brilliant cresyl blue (BCB). The exact method of preparing the dye-reagents is as follows : To one of the two separate lots of

100 ml warm distilled water is dissolved 10 mg of thionine and to the other the same quantity of brilliant cresyl blue. Then to both of these are added 100 ml of $HClO_4$ and an equivalent quantity of conc. H_2SO_4. The pHs of these two reagents are 0.2 and 0.4 respectively. The colour of the pale green thionine dye-reagent is not lost after storage at room temperature for 24 h; while the pale brown brilliant cresyl blue dye-reagent changes to pale green colour during the same length of time.

The different organic compounds tested to give positive or negative colour reactions are listed in Table 1, showing different colours when the compounds are allowed to react with the dye-reagents. It is evident that thionine and BCB dye-reagents prepared with perchloric and sulphuric acids are highly suitable for the detection and characterisation of several organic compounds, belonging to different groups, including some solid ones.

The interesting fact is that thionine dye-reagent when allowed to react with the alcohols shows the development of a blue ring. On shaking, however, the entire mixture becomes sky-blue. Amongst the aldehydes, the solid compounds, viz. p-hydroxy benzaldehyde, vanillin and veratraldehyde can even be identified. The liquid ones can also be identified by colouration and such is the case with ketones. The amines, four of which have been tested, can also be characterised. Amongst the several carboxylic acids and ethers tested, linoleic and oleic acids of the former group and anisole and phenetole of the latter give very characteristic colour reactions which are very different from the usual blue colour produced with the majority of the compound-dye-reagent mixtures.

In the case of BCB dye-reagent, alcohols cannot be characterised. However, in some cases of alcohols, a blue or green ring is developed. Amongst phenols, resorcinol and quinol appear to show yellow colour on standing for 20 min. In the case of the five ketones tested, cyclohexanone produces a pale orange colour and acetone a green ring. Amongst the six aldehydes tested, only glutaraldehyde can be characterised with this dye-reagent. Linoleic and oleic acids when mixed with this reagent show an orange colour. Amongst amines, only pyridine produces effervescence and then becomes deep blue. Of the five ethers, only dioxane shows a green ring.

Thionine and BCB dye-reagents when mixed with tap or distilled water become hot and show colours. With the addition of conc. NaOH to these dye-reagents, there is considerable effervescence followed by development of a colour with heat production. With the addition of conc. HCl, only sky-blue or pale green colour is developed with the two dye-reagents.

In the author's earlier investigation[1] dealing with thionine dye-reagent, prepared with N H_2SO_4 and sodium sulphide, the colour reactions with the different organic compounds were found to be totally different from those of the present set of reactions as judged by the colouration produced on mixing the dye-reagent with the compounds. Nevertheless, thionine dye-reagents prepared by the above method and the present one are highly suitable for detecting some organic compounds, both solid as well as liquid ones. However, the slight difference between the reaction quality of the two dye-reagents is that with the present dye-reagent, three solid compounds could not be detected through colour formation, whereas with the former dye-reagent, all the solid as well as the liquid ones can be detected.

In another communication[2] by the author, it was also reported that brilliant cresyl blue, decolourised with N H_2SO_4 and $Na_2S.2H_2O$, can be used for detecting some organic compounds. This dye-reagent appeared to be pale straw in colour. Reactions of all the compounds used in that study were found to exhibit colours which are very different from those obtained in the present study. In the present study, this

TABLE 1 : Reaction of some organic compounds with a new variety of dye-reagents

Compound	Thionine	Brilliant cresyl blue
I. *Alcohols*		
(a) Methanol	+ve (blue-ring)	+ve (blue-ring ; on shaking green)
(b) Ethanol	+ve („)	+ve (green-ring)
(c) n-Propanol	+ve („)	+ve („)
(d) iso-Propanol	+ve („)	+ve (green, above a blue ring)
(e) n-Butanol	+ve („)	+ve („)
(f) iso-Butanol	+ve („)	+ve (blue green ring)
(g) tert-Butanol	+ve („)	+ve (green, above a blue ring)
(h) n-Pentanol	+ve („)	+ve (only green ring)
II. *Phenols*		
(a) Phenol	+ve (pale blue-green)	—ve
(b) Resorcinol	+ve (upper colourless ; lower pale yellow)	+ve (golden yellow—on standing)
(c) Quinol	+ve (upper colourless ; lower ext. pale green)	+ve („)
III. *Aldehydes*		
(a) Formaldehyde	+ve (blue)	+ve (immediately green)
(b) Glutaraldehyde	+ve (upper blue ; lower orange)	+ve (deep orange)
(c) Paraldehyde	+ve (upper pale blue ; lower original)	+ve (pale green)
(d) p-hydroxy benzaldehyde	+ve (upper colourless ; lower dirty brown)	+ve (paler than original)
(e) Vanillin	+ve (upper colourless ; lower blue-green)	+ve (slightly pale green— on standing)
(f) Veratraldehyde	+ ve (upper colourless ; lower moss green)	+ve (deep green)
IV. *Ketones*		
(a) Acetone	+ve (sky-blue ; soon colourless ; then pale yellow)	+ve (upper blue ; green ring)
(b) Methyl Ethyl ketone	+ve (pale yellow)	+ve (pale green)
(c) Cyclohexanone	+ve (orange)	+ve (pale orange)
(d) Acetophenone	+ve (greenish-yellow)	+ve (slightly clowdy green)
(e) Benzophenone	—ve	+ve (slightly paler green)
V. *Carboxylic acids*		
(a) Formic acid	+ve (sky-blue)	+ve (green)
(b) Acetic acid	+ve („)	+ve („)
(c) Linoleic acid	+ve (upper deep brown ; lower orange)	+ve (orange)
(d) Oleic acid	+ve („)	+ve („)
(e) Phenylacetic acid	—ve	+ve (slightly paler than original)
(f) Phthalic acid	—ve	+ve („)
VI. *Amines*		
(a) Ethyl amine	+ve (sky-blue)	+ve (green)
(b) Tributylamine	+ve (upper brown ; lower colourless)	+ve (upper yellow ; lower pale green)
(c) Dimethylaniline	+ve (deeper green than original)	+ve (deep blue)
(d) Pyridine	+ve (thick white ppt ; effervescence)	+ve (slight effervescence ; deep blue)
VII. *Ethers*		
(a) Solvent ether	+ve (sky-blue)	+ve (pale green)
(b) Anisole	+ve (upper colourless ; lower yellowish-green)	+ve (requires thorough shaking ; lower pale green)
(c) Phenetole	+ve (upper ext. pale pink ; lower original)	—ve
(d) Dioxane	+ve (sky-blue)	+ve (green ring)
(e) Tetrahydrofuran	+ve („)	+ve („)

dye-reagent was prepared with $HClO_4$ plus H_2SO_4. The pHs of the dye-reagents are also different, being 10.0 in the previous experiment and 0.4 in the present one. Not only this; solid organic compounds could not be tested with the former dye-reagent as solvent ether and chloroform; in which these compounds can be dissolved, reacted with it. However, since chloroform does not give positive colour reaction with thionine or BCB dye-reagents; as presented herein, solid organic compounds which could be dissolved in this solvent can be tested.

Therefore, it can be concluded that the reactions of the organic compounds with these dye-reagents may only be due to chemical reactions in which the different reactive groups of the compounds are interacting with those of the dye molecules, producing colours. Both thionine as well as BCB dye-reagents are not acted upon by UV rays. With warming, slight change of colour towards blue occurs with thionine dye-reagent. This dye-reagent gets completely decolourised on heating and the reagent then becomes useless. BCB dye-reagent; on being heated, becomes deep moss green but the reagent remains active.

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Effect of *Celosia argentea* Linn. on root nodules and nitrogen contents of three legume crops

Specific *Rhizobium* species form nodules on the roots of specific leguminous plants (host) where the relationship is symbiotic. The *Rhizobia* in the root nodules are able to fix atmospheric nitrogen which, in turn, is available to the host plant for its growth. A leguminous plant upon formation of root nodules becomes independent of soil nitrogen. Non-leguminous plants; in association with leguminous plants, often decrease in the latter the number of nodules and their nitrogen-fixing capacity[7]. Thus, nitrogen supply becomes low and associated non-leguminous species get a selective competitive advantage over the leguminous species which have higher nitrogen requirements[4,5]. Pandya and Pota[6] reported inhibitory effect of root-exudates from the weed *Celosia argentea* Linn. on the proliferation of *Rhizobium meliloti* Dangeard obtained from root nodules of *Trigonella foenum-graecum* Linn. Therefore, further studies were made with a view to finding out nitrogen contents of commonly grown leguminous crops at Rajkot as affected by associated *C. argentea*.

In the present study, seeds of the weed were collected from the local crop fields. The seeds of three leguminous crops commonly cultivated in the Gujarat State, viz. *Cajanus cajan* (Linn.) Mill. cv. T-15-1 (thuar), *Vigna* (= *Phaseolus*) *aconitifolius* (Jacq.) Marechal cv. 15-7 (math) and *Phaseolus aureus* Roxb. cv. Guj-2 (mung) were obtained from Junagadh Campus of the Gujarat Agriculture University.

From these seed stocks, plants were raised in earthen pots size (26 cm d × 23 cm h) containing silty clayey soil mixed with green manure at the rate of 100 g per kg soil. Upon emergence and seedling growth, only four crop plants/pot in pure culture and two crop plants with two weed plants/pot in mixed culture were maintained. Both the sets were made in triplicate, having a total of sixty pots in which the plants were grown. Plants of both cultures were collected on 10, 20; 40, 60 and 80 days after emergence of the crop plants. The number of roots nodules (only pank or reddish) in each of the leguminous species was counted. Then the crop and the weed plants were cut and separated into shoot (aboveground biomass) and root (belowground biomass). The biomass was then dried in oven at 80°C till constant weight. The dried biomass was then powdered and analysed for total nitrogen contents by micro-kjeldahl method[8].

Root nodules increased with increase in age of the three crop plants under the pure cultures (Fig. 1). However, in the mixed cultures, root nodules per leguminous plants of thuar and math decreased. But in mung, there was an increase in the number of root nodules in association with the weed plants. Thus, the weed inhibited root-nodule formation in plants of thuar and math but it stimulated in mung plants. Number of the root nodules also affected the total nitrogen content of the crop plants (Fig. 2). The crop plants of thuar and math showed more root nodules and higher percentage of total nitrogen in the pure culture than that under the mixed cultures. But in case of mung plants, it was reverse.

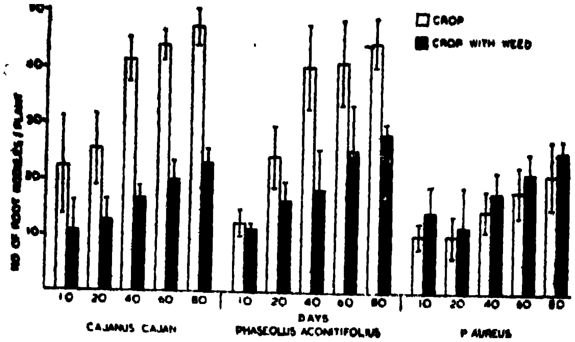

Fig. 1. Effect of *Celosia argentea* on the number of root nodules in three leguminous plants grown in pure and mix cultures at different time of their growth (*Phaseolus aconitifolius* syn. *Vigna aconotifolius)*

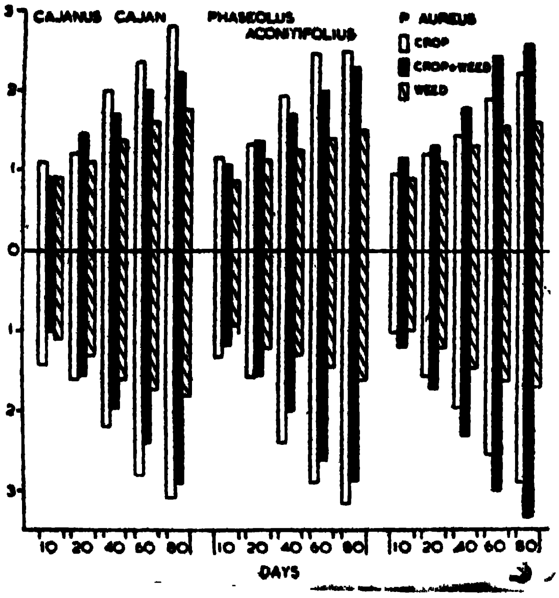

Fig. 2. Total nitrogen contents expressed as per cent dry weight in the crop and the weed plants grown in pure and mix cultures

Rhizobia from the root nodules of the respective leguminous plants were isolated as per Vincent[8] and were tested for the species as per Buchanan and Gibbons[1] and Rao[7]. The *Rhizobia* in all the three species of the leguminous plants belong to the *Rhizobium*—cowpea miscellany.

Inhibition of the growth of *Rhizobium meliloti* by root-exudates of *C. argentea* have been reported[9]. Hence, it is presumed that the differential effects, i.e. inhibitory and stimulatory, of the weed plants on the root nodules are probably related to the nature of the root nodules and differences in the crop species. Moreover, it is presumed that in thuar and math, the *Rhizobia* in the nodules are not protected from the inhibitory effect of the associated weed plants. In mung, some type of protection is provided by the legume plant or the secretion of the respective crop plants must be neutralizing the inhibitory effect of the weed plants. Further investigations in this line are in progress.

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Effect of vitamins on the regeneration of adventitious roots

Treatment with vitamins has been found to promote root formation in cuttings[1,4]. The beneficial effect of nicotinamide, ascorbic acid, pyrodoxine and thiamine on root initiation of *Justicio gendarussa* cuttings was recorded[1]. In this paper are presented the results on the effect of vitamins on the rooting in cuttings of *Ixora singaporensis*.

Healthy plants of *I. singaporensis* were selected and sprayed with vitamins viz. ascorbic acid, nicotinic acid, folic acid, pyrodoxine and thiamine at 50, 100 and 500 ppm. Spraying with distilled water served as the control. Seven days after treatment, tip cuttings, about 25 cm in length were taken from healthy shoots and only the upper four leaves and the apical bud were retained. The cuttings were planted in washed sand and kept inside the green house. There were altogether sixteen treatments which were replicated four times. Data on the percentage of cuttings rooted, number of roots per cutting and root length were recorded, 21 days after planting.

Pre-planting treatment with vitamins, improved rooting in cuttings of *Ixora singaporensis*, except the higher two (100 and 5000 ppm) concentration of thiamine (Table 1). Cuttings taken from the ascorbic acid at 100 ppm pre-treated stock plant showed 95 per cent rooting with 13.4 roots in each cutting compared to 46.7 per cent rooting with 6.1 roots per cutting in control. Root production was also enhanced due to nicotinic acid, folic acid and pyrodoxine pre-treatment, and among the three concentrations, nicotinic acid at 100 and 500 ppm, folic acid at 100 ppm and pyrodoxine at 50 ppm proved effective in rooting of *Ixora singaporensis*. Pre-treatment with ascorbic acid and folic acid, in general, increased the mean length of root. The variation was, however, not significant. The mechanism of promotion of rooting due to vitamin application is not yet clear. However, the growth-promoting activity of many of the vitamins

TABLE 1 : Effect of vitamins on the rooting of *Ixora singaporensis*

Treatment		Percentage of cuttings rooted	Number of roots/cutting	Length of roots (cm)
Control		46.7 (43.07)	6.1	3.46
Ascorbic acid	50 ppm	80.0 (63.43)	12 1	4.06
	100 ppm	95.0 (78.20)	13.4	4.03
	500 ppm	88.3 (72.19)	11.3	3.93
Nicotinic acid	50 ppm	76.7 (61.21)	10.1	3.93
	100 ppm	80.0 (63.43)	10.8	3.66
	500 ppm	80.0 (63.43)	10.5	3.66
Folic acid	50 ppm	71.7 (57.98)	9.7	3.70
	100 ppm	80.0 (63.73)	8.9	4.23
	500 ppm	61.7 (51.75)	8.5	4.33
Pyrodoxine	50 ppm	63.3 (52.74)	8.4	3.70
	100 ppm	60.0 (50.77)	7.8	3.53
	500 ppm	55.0 (47.89)	8.0	3.56
Thiamine	50 ppm	48.3 (44.01)	8.1	3.26
	100 ppm	41.7 (40.11)	7.2	3.76
	500 ppm	41.7 (40.19)	7.2	3.63
S. Em ±		4.20	0.56	0.22
C. D. at 5%		8.58	1.16	N. S.

(Angular transformed values are presented in parenthesis) might be due to their active participation in different metabolic reactions, which are essential constituent of a number of enzyme system. Ascorbic acid acted as an important growth regulator in plants and its involvement in nuclic acid metabolism has also been demonstrated[4].

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Cytology of hybrids of the *Solanum nigrum* L. complex

The excellent studies of earlier workers give us to some extent a good exposition of taxonomic and biosystematic problems of the *Solanum nigrum* complex[1], but significant information is not known regarding the genetic factors of morphological divergence of members of the complex. The present paper deals with such studies as revealed by meiotic behaviour of chromosomes of hybrids of the two taxa of the *S. nigrum* complex.

Using Indian hexaploid *Solanum nigrum* L. and *S. nigrum* L. ssp. *schultesii* (opiz.) Wessely, meiosis was studied in squashes of pollen-mother cells fixed in Carnoy's fluid and made permanent with butyl alcohol. Pollen fertility was determined by stainability in acetocarmine.

The two taxa are hexaploids ($2n=72$) with purplish black fruits. Several reciprocal cross pollinations between them were successful and the reciprocal hybrids were cytomorphologically alike. The F_1 hybrids were hexaploids ($n=36$) which produced bluish black fruits with viable seeds. Their pollen stainability values averaged 81.24%. Fertile progeny was raised from F_1 hybrids. Their average pollen stainability value was 74.31%.

The hexaploid S. *nigrum* and *S. nigrum* ssp. *schultesii* showed normal meiosis with 36 bivalents ; in the former, the frequency of chiasmata, per bivalent, was 1.04 while in the latter it was 1.14.

The F_1 hybrids displayed mostly normal chromosome behaviour. However, a few cells showed univalents and multivalents. At metaphase I, the mean chromosome pairing, per cell, was $1.08_{\mathrm{I}}+34.80_{\mathrm{II}}+0.20_{\mathrm{III}}+0.16_{\mathrm{IV}}$. The frequency of chiasmata, per bivalent, was 1.20. In 90% of the cells, anaphase I was normal with 36 chromosomes at each pole. In 2% of the cells, lagging chromosomes (1 or 2) were observed. The chromatin bridges without fragments were recorded in 2% of the cells. Micronuclei were not recorded at telophase I and II.

In F_2 plants, at metaphase I, a number of cells were observed to have 36 bivalents. In a few cells, some multivalents and univalents were also encountered. At metaphase I, the mean pairing of chromosomes, per cell, was $0.68_{\mathrm{I}}+35.26_{\mathrm{II}}+0.20_{\mathrm{IV}}$ and the frequency of chiasmata, per bivalent, was 1.20. Anaphase I was normal in 86% of the cells with 36 chromosomes at each pole. Lagging chromosomes were recorded in 2% of the cells ; bridges and fragments were not observed. Micronuclei were not recorded at telophase I and II.

The cytological features of the F_1 and F_2 hybrids perhaps denote the possession of common genetic architecture of the parents. The absence of multivalents in parents, and their appearance in low frequency in some pollen-mother cells of F_1 hybrids may denote the allosyndetic pairing of majority of chromosomes of the latter. The occurrence of a few univalents, in some cells of the F_1 hybrids, may indicate the existence of genic differences of the two parental taxa ; the occasional appearance of bridges without fragments in some cells may also indicate the presence of structural differences of chromosomes of the parents. The failure to observe the structural differences between the parental chromosomes may be due to their too small size to be detected cytologically[2]. From these studies, it is suspected that the gene mutations and hidden structural differences between parental chromosomes[3], are responsible for reduction of pollen fertility in F_1 hybrids as compared to the parents.

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Inheritance of leaflet shape in pigeon pea

The obcordate and round leaflet mutations in pigeon pea [*Cajanus cajan* (L.) Millsp.] were first reported by Singh *et al*[1]. and Pandya *et al.*[2] respectively. While oblong-obovate mutation was detected by Divakaran and Rambhadran[3].

A cross was made between 'Round leaf' and 'Obcordifolia' (N. Black) mutants in Botany Section, College of Agriculture, Pune in 1968. The behaviour in F_1, F_2 and F_3 generations were observed in subsequent years. The Round-leaf parent had round leaflets while Obcordifolia (N. Black) had obcordate-connate leaflets. The hybrid showed obovate leaflets which were described as oblong-obovate[3]. The F_2 population of 224 individuals segregated into seven phenotypic classes (Fig. 1) which yielded a trihybrid ratio of 27:9:9:9:3:3:4. Here

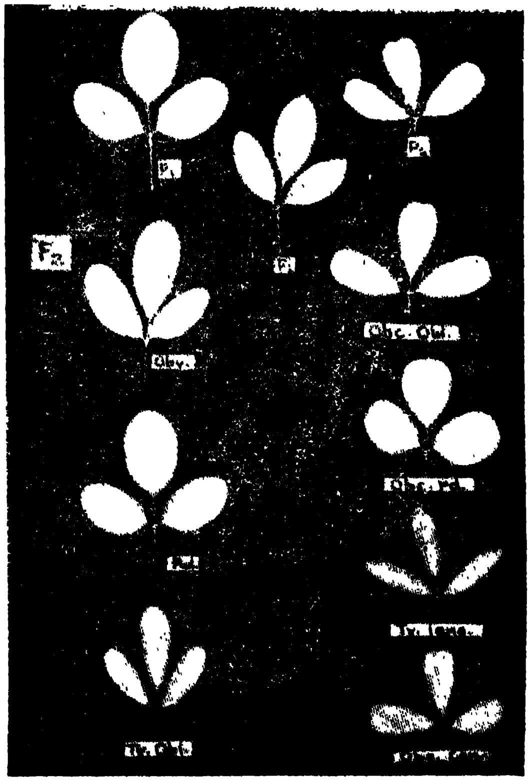

Fig. 1.

TABLE 1 : Segregation of leaflet shape in F_2

Class	Abbreviation	Observed	Expected 27 : 9 : 9 : 9 : 3 : 3 : 4	Genes involved
Obovate (Hybrid type)	Obv.	86	94.5	Llt, Rlt and Clt
Round (Parental type)	Rd.	34	31.5	Llt and Rlt
Tiny oblong	Ty-obl.	24	31.5	Llt and Clt
Obcordate oblong	Obc-obl.	38	31.5	Rlt and Clt
Tiny lanceolate	Ty-lanc.	14	10.5	Llt
Obcordate round	Obc-Rd.	15	10.5	Rlt
Obcordate-connate (Parental type)	Obc-conn.	13	14.0	Clt or llt, rlt and clt

Total X^2 = 7.2259 P = 0.30-0.50

the last two classes of the direct trihybrid ratio of 27:9:9:9:3:3:3:1 have been added together. The results obtained are presented in Table 1.

It is seen from Table 1 that the leaflet shape was governed by three factors which are symbolized as Llt, Rlt and Clt[4]. The gene Llt was responsible for lanceolate leaflet shape while round leaflet was produced by Rlt and Llt. The genes Clt and Llt gave

TABLE 2 : Genotypic constitution of 60 F_2 families for leaflet shape

F_2 phenotype	F_3 behaviour	Expected ratio	No. of families	
			Observed	Expected
1	2	3	4	5
Obovate	Breeding true	1	0.0	0.93
	3 Obv : 1 Rd.	2	4.0	1.88
	3 Obv : 1 Obc-Obl.	2	2.0	1.88
	3 Obv : 1 Ty-Obl.	2	3.0	1.88
	9 Obv : 3 Rd : 3 Obc-Obl : 1 Obc-Rd.	4	2.0	1.88
	9 Obv : 3 Rd : 3 Ty-Obl : 3 Ty-lanc.	4	1.0	3.75
	9 Obv : 3 Obc-Obl : 3 Ty-Obl : 1 Obc-conn.	4	4.0	3.75
	27 Obv : 9 Rd : 9 Ty-Obl : 9 Obc-Obl : 3 Ty-lanc : 3 Obc-Rd : 4 Obc-conn.	8	6 0	7.42
	X^2 = 0.4328 P = < 0.99			
Round	Breeding true	1	1.0	0.93
	3 Rd : 1 Obc-Rd.	2	0.0	1.88
	3 Rd : 1 Ty-lanc.	2	1.0	1.88
	9 Rd : 3 Ty-lanc : 3 Obc-Rd : 1 Obc-conn.	4	4.0	3.75
	X^2 = 0.7054 P = 0.80-0.90			
Tiny oblong	Breeding true	1	2.0	1.88
	3 Ty-Obl : 1 Obc-conn.	2	5.0	1.88
	3 Ty-Obl : 1 Obc-Rd.	2	0.0	1.88
	9 Ty-Obl : 3 Obc-Rd : 4 Obc-conn,	4	0.0	3.75
	X^2 = 0.2456 P = 0.95-0.98			
Obcordate oblong	Breeding true	1	1.0	0.93
	3 Obc-Obl : 1 Obc-conn.	2	4.0	1.88
	3 Obc-Obl : 1 Obc-Rd.	2	1.0	1.88
	9 Obc-Obl : 3 Obc-Rd : 4 Obc-conn.	4	3.0	3.75
	X^2 = 0.0371 P = < 0.99			
Tiny lanceolate	Breeding true	1	2.0	0.93
	3 Ty-lanc : 1 Obc conn.	2	6.0	1.88
	X^2 = 9.5858 P = 0.01-0.001			
Obcordate round	Breeding true	1	1.0	0.93
	3 Obc-Rd : 1 Obc-conn.	2	4.0	1.88
	X^2 = 1.7067 P = 0.10-0.20			
Obcordate connate	Breeding true	4	3.0	3.75
	X^2 = 0.15 P = 0.50-0.70			

Total X^2 = 33.1923 D. F. = 24 P = 0.10-0.20

rise to tiny-oblong leaflet shape. The obcordate leaflet was realised in the absence of dominant condition of Llt which was further classified into three distinct phenotypes; viz. obcordate-oblong, obcordate-round and obcordate-connate. These three types were caused by the other two genes, Rlt and Clt. The factor Rlt and Clt together produced obcordate-oblong leaflet, Rlt produced obcordate-round and factor Clt alone or recessive alleles of all the three genes gave obcordate-connate leaflets.

One of the two parents, i.e. Round-leaf mutant carries two dominants factors Llt and Rlt and the other parent having obcordate connate leaflet shape has only one gene Clt. With the union of these three dominant genes in the hybrid, a remote ancestral trait; i.e. obovate leaflet shape reappeared. With the reunion of two genes Llt and Rlt, a new round-leaf type and with Rlt and Clt; a new type of obcordate-oblong reappeared. Separation of gene Llt from the parent Round gives rise to tiny lanceolate leaflet shape. Rlt assumed the shape of obcordate round type. This is a typical case atavism; throwback or reversion in the plant character involving three genes. This kind of behaviour is being reported for the first time.

Sixty F_3 families were raised from 60 F_2 random individuals in order to confirm the genetic behaviour observed in F_2 generation. The results are presented in Table 2. In some classes; the observed frequency is zero which is most probably due to a small number of F_3 (60) families which involved 25 genotypic classes in F_3 behaviour. The probability level for each of the phenotypic class excepting one, is good and the value of total X^2 is also reasonably low and yielded a probability level of 0.10 to 0.20. Thus; F_2 observations are confirmed by genetic behaviour of F_3 generation.

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Effect of sublethal dosages of insecticides on the population dynamics of pulse beetle, *Callosobruchus chinensis* L.

Involvement of factors other than the destruction of parasites; predators or other bioagents of natural control seem to exist in the mechanism of pest resurgence but remains yet to be fully investigated. Since under the field condition; individuals of a pest population are not equally exposed to the lethal concentrations of insecticides and that a portion of it gets an exposure to concentration not lethal or sublethal to individuals, the present investigation was taken up to find out the effect of sublethal dosages of different organophosphorus insecticides on the population dynamics of pulse beetle, *Callosobruchus chinensis* L.

Sublethal concentration has been defined here as a concentration, value of which is below LC_{50}. It has recently been observed[1] that resurgence of pests may occur after their exposure to sublethal dosages of insecticides.

To evaluate the effect of such exposure to sublethal concentrations of insecticides, a series of experiments was carried out by exposing 3-day-old laboratory reared adults of *C. chinensis* to three levels of sublethal dosages of five different organophosphorus insecticides, *viz.* Diazinon, Fenitrothion, Fenthion, Methyl demeton and Dimethoate.

Values of LC_{50} of these five different organophosphorus insecticides were evaluated against the 3-day-old adults of *C. chinensis* by exposing them to dry films of different insecticides on both the inner surfaces of 9 cm petri dishes @ 1 ml per petri dish pair; for an exposure period of 1 hour (Table 1). Values of sublethal concentrations at three levels *viz.* LC_{40}; LC_{30} and LC_{20} were sub-

TABLE 1 : LC_{50} values of different insecticides to 3 days old adults of *C. chinensis* for an exposure period 1 hr in dry film

Insecticide	Trade name	Heterogeneity	Regression equation Y =	LC_{50} value (% ai)	Fiducial limits
Diazinon	Bezanon	$K^2(_5) = 0.189$	$1.29X + 3.69$	1.00	0.70 1.30
Fenitrothion	Sumithion	$K^2(_6) = 2.39$	$1.28\overset{*}{X} + 2.86$	0.0046	0.0043 0.0049
Fenthion	Lebaycid	$K^2(_4) = 0.20$	$1.16\overset{**}{X} + 3.03$	0.005	0.003 0.006
Methyl demeton	Metasystox	$K^2(_3) = 0.097$	$1.57\overset{*}{X} + 2.66$	0.031	0.025 0.037
Dimethoate	Rogor	$K^2(_3) = 0.35$	$1.23\overset{*}{X} + 3.53$	0.016	0.012 0.020

Y = Probit kill; X = log (conc. × 10^2); $\overset{*}{X}$ = log (conc. × 10^3)
$\overset{**}{X}$ = log (conc. × 10^4)

sequently evaluated and presented in Table 2. Three days old adult males and virgin females of *C. chinensis* were subsequently exposed, sexwise, to each of these three sublethal concentrations of five different insecticides for 1 hr. A treated male and a treated female were then released together, sublethal concentrations wise, in 15 cm diam Petri dish containing insect-free fresh gram for mating and oviposition as well as for observations on survivality for ascertaining the nature of population dynamics due to treatments. Survivality of the treated adults and the reproductivity of the treated females over control treatments at three levels of sublethal dosages have been presented in Table 3.

It may be seen from Table 3 that survivality of both adult males and females, exposed to different levels of sublethal dosages decreased in comparison to the untreated ones. The treated females, however, showed higher survivality than that of treated males. Reduction in the period of survivality also implied corresponding reduction in the period of oviposition. The maximum average decline in ovipositional period to the extent of (−) 32.19 per cent over control occurred in case of exposure of the pest to the sublethal concentration of Dimethoate at the level of LC_{40} while the minimum decrease in the ovipositional period to the extent of (−) 2.70 per cent over the control occurred in case of exposure to the sublethal concentra-

TABLE 2 : Values of sublethal concentrations of different insecticides at the levels of LC_{40}, LC_{30} and LC_{20}

Insecticide	Level of sublethal concentration	Values (% ai)	Fiducial limits
Diazinon	LC_{40}	0.06	0.05 0.07
	LC_{30}	0.04	0.03 0.05
	LC_{20}	0.02	0.014 0.026
Fenitrothion	LC_{40}	0.0032	0.0028 0.0036
	LC_{30}	0.0018	0.0015 0.0021
	LC_{20}	0.0010	0.0007 0.0013
Fenthion	LC_{40}	0.003	0.0021 0.0039
	LC_{30}	0.0018	0.0015 0.0021
	LC_{20}	0.0009	0.0003 0.0015
Methyl demeton	LC_{40}	0.021	0.016 0.026
	LC_{30}	0.014	0.010 0.018
	LC_{20}	0.009	0.004 0.014
Dimethoate	LC_{40}	0.010	0.007 0.013
	LC_{30}	0.006	0.004 0.008
	LC_{20}	0.003	0.001 0.005

TABLE 3 : Survivality and reproductivity of adults of *C. chinensis* exposed to three levels of sublethal concentrations of different insecticides

Temp. 28—31°C
Mean of 10 Observations

Insecticide	Levels of sublethal conc. & their values (% ai)	Survivality				Ovipositional period		Reproductivity per female		Fecundity/day/female	
		Male		Female		Days (No.)	% increase (+)/decrease (—) over control	Fecundity (No.)	% increase (+)/decrease (—) over control	No.	% increase (+)/decrease (—) over control
		Days (No.)	% increase (+)/decrease (—) over control	Days (No.)	% increase (+)/decrease (—) over control						
Diazinon	LC_{40} — 0.06	8.70	(—) 32.73	11.9	(—) 17.93	8.6	(—) 27.1	70.1	(+) 3.96	8.15	(+) 42.23
	LC_{30} — 0.04	8.90	(—) 27.04	12.8	(—) 11.72	9.8	(—) 16.9	70.0	(+) 3.55	7.14	(+) 24.61
	LC_{20} — 0.02	9.50	(—) 22.13	13.1	(—) 9.65	10.1	(—) 14.4	69.2	(+) 2.36	6.85	(+) 19.54
	Control —	12.2	—	14.5	—	11.8	—	67.6	—	5.73	—
Fenitrothion	LC_{40} — 0.0032	9.3	(—) 26.19	11.1	(—) 23.97	8.1	(—) 25.0	82.0	(+) 26.35	10.12	(+) 68.39
	LC_{30} — 0.0018	9.9	(—) 21.42	11.9	(—) 18.49	8.5	(—) 21.3	69.1	(+) 6.45	8.12	(+) 35.11
	LC_{20} — 0.0010	10.5	(—) 16.66	12.5	(—) 14.36	9.2	(—) 14.8	67.7	(+) 4.31	7.34	(+) 23.13
	Control —	12.6	—	14.6	—	10.8	—	64.9	—	6.01	—
Fenthion	LC_{40} — 0.003	9.2	(—) 23.98	11.5	(—) 19.58	8.2	(—) 25.79	73.6	(+) 9.69	8.97	(+) 49.75
	LC_{30} — 0.0018	10.1	(—) 16.52	12.2	(—) 14.68	9.2	(—) 17.86	71.1	(+) 5.96	7.72	(+) 28.88
	LC_{20} — 0.0009	10.6	(—) 12.38	12.9	(—) 9.79	9.8	(—) 12.5	70.8	(+) 5.51	6.20	(+) 3.51
	Control —	12.1	—	14.3	—	11.2	—	67.1	—	5.99	—
Methyl demeton	LC_{40} — 0.021	10.3	(—) 16.93	12.6	(—) 12.5	9.5	(—) 14.41	91.8	(+) 36.40	9.66	(+) 59.41
	LC_{30} — 0.014	11.2	(—) 9.67	13.3	(—) 7.63	10.5	(—) 5.41	84.4	(+) 25.41	8.03	(+) 32.59
	LC_{20} — 0.009	11.5	(—) 7.25	13.8	(—) 4.16	10.8	(—) 2.70	76.6	(+) 13.82	7.09	(+) 16.99
	Control —	12.4	—	14.1	—	11.1	—	67.3	—	6.06	—
Dimethoate	LC_{40} — 0.010	8.1	(—) 31.93	10.8	(—) 25.17	7.5	(—) 31.19	69.7	(+) 3.72	9.29	(+) 50.81
	LC_{30} — 0.006	9.2	(—) 22.68	11.6	(—) 21.88	8.2	(—) 21.97	68.1	(+) 1.34	8.30	(+) 34.71
	LC_{20} — 0.003	9.7	(—) 18.48	12.8	(—) 12.24	9.1	(—) 16.52	67.5	(+) 0.45	7.41	(+) 20.29
	Control —	11.9	—	14.7	—	10.9	—	67.2	—	6.16	—

tion of Methyl demeton at the level of LC_{20}, amongst the five insecticides tested. It was also observed that decrease in survivality of the pest due to treatments was followed by an increase in reproductivity. There was increase in per day fecundity per treated female leading to an overall increase in total fecundity per treated female over that of the untreated control. Increase in fecundity per day per treated female ranged from (+) 42.23 to (+) 68.39 per cent in case of exposure to sublethal dosages of these five insecticides at the level of LC_{40}. The rate of per-day-fecundity per treated female gradually decreased with decrease in the level of the sublethal concentrations below LC_{40}. Eggs laid by the treated females were also found to be viable. Similar trend of increase in population has also been reported by other workers[2-4].

Observations also showed that the pattern and proportion of increase in the population of *C. chinensis* when exposed to sublethal concentrations of different insecticides tend to vary from insecticide to insecticide. Results of the investigation indicate that exposure of pests to sublethal concentrations of insecticides in the field during insecticidal operations for pest control will have a tendency to stimulate increased oviposition and consequent rise in population and its resurgence and that there is a scope for selection of proper insecticide for pest control where increase in population due to exposure to sublethal dosages would be minimum.

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Comparative pollen spectra of honey samples from West Dinajpur and Jalpaiguri Districts of West Bengal

Honey contains a large number of pollen grains that are collected by the visiting bees. Analysis of the pollen types from honey samples reflects the preference and choice of the plant types and also location of honey-yielding plants of the adjoining areas. Quantitative analysis of the honey would also reflect the coherence between the pollen types that are originating from two different areas[1].

In the present paper, qualitative and quantitative analysis of the honey samples from Balurghat (West Dinajpur District) and Jalpaiguri (Jalpaiguri District) of West Bengal, India were made with a view to compare the pollen frequencies and also to ascertain the composition of the honey sediments of two different areas. Characterization of the pollen types and mode of pollinations were also recorded.

Method for the pollen analysis of the honey samples was adopted partly according to Louveaux *et al*[2]. Two honey samples were diluted with 20 ml of distilled warm water, centrifuged and the water was decanted. Pollen samples were prepared following acetolysis[3]. Morphological characters were studied by using Leitz Laborius microscope.

All together 22 pollen types have been recorded from the honey samples of Balurghat and Jalpaiguri. Some of the pollen types were common in between the samples, whereas other types were typical representatives of the adjoining flora.

The pollen of *Azadirachta indica* was represented by highest pollen frequency (40.0%) in Balurghat sample whereas the same pollen was represented less (13.5%) in Jalpaiguri sample (Table 1). The other dominant pollen type of Balurghat was *Blumea lacera* represented by 21.1% pollen frequency and this type was absent in Jalpaiguri sample. *Coriandrum sativum* was represented by highest pollen frequency (19.0%) in Jalpaiguri sample which was found to be absent in Balurghat sample.

TABLE 1 : Comparative account of the pollen content of honey samples of Balurghat (West Dinajpur District) and Jalpaiguri (Jalpaiguri District)

Name	Pollination Mechanism	Balurghat (%)	Jalpaiguri (%)
Aegle marmelos	E	—	6.0
Ageratum conyzoides	E	2.0	—
Azadirachta indica	E	40	13.5
Blumea lacera	E	21.1	—
Bombax ceiba	E	5.8	1.5
Borassus flabellifer	E	8.0	9.0
Brassica juncea	E	5.8	—
Cassia sophera	E	4.0	3.0
Casuarina equisetifolia	A/E	—	4.5
Colocasia esculenta	E	2.0	—
Coriandrum sativum	E	—	19.0
Croton bonplandianum	A/E	—	9.0
Datura metel	E	4.0	—
Desmodium sp.	E	—	6.0
Holarrhena antidysenterica	E	2.0	4.5
Hygrophila sp.	E	5.8	—
Leucas sp.	E	5.8	1.5
Polygonum sp.	E	13.4	—
Psidium guyava	E	—	4.5
Solanum sp.	E	5.8	4.5
Vernonia cinerea	E	—	9.0
Zizyphus jujuba	E	10.5	4.5

E = Entomophilous ; A/E = Amphiphilous.

Pollen spectra of both the samples showed a diversity of pollen types; some of which originating from both cultivated and wild types. The represented types mostly originated from entomophilous plants except *Croton bonplandianum* and *Casuarina equisetifolia*. These two amphiphilous types were recorded from Jalpaiguri sample only.

The characteristic features of the pollen types were studied with regard to their aperture; shape, size and ornamentation (Table 2). 3-colporate apertural condition was dominant and represented by *Ageratum conyzoides*; *Blumea lacera*; *Bombax ceiba*, *Cassia sophera*, *Coriandrum sativum*; *Datura metel*, *Desmodium* sp.; *Psidium guyava*, *Solanum* sp.; *Vernonia cinerea*, *Zizyphus jujuba*, etc. The other apertural forms like 4-colporate, 3-5 porate; 3-pororate; 1-sulcate inaperturate and pantoporate pollen grains were also encountered in the samples. The shape of the recorded pollen types varied from prolate; prolate-speroidal; oblate-speroidal and oblate etc., types. The surface ornamentation of the recorded pollen types were dominated by punctitegillate to reticulate forms[4]. There were few instances of pollen types with echinate or psilate ornamentations (Table 2).

The present study on the comparative account of pollen spectra of two honey samples; showed an assemblage of pollen types originating mostly from wild plants. Pollen from the cultivated variety of plants were less frequently represented. Probably the bees have a choice over a wide range of wild plant types which may be due to availability of large quantity pollen or nectar from these plants. Collection of pollen from alternative plant sources is important which is dependent on the flowering time of the available flora and also preference of honey bees to certain specialised morphological characters of pollen exhibited by entomophilous plants. From the present study, the location of honey and pollen-yielding plants of the flora that are preferred by the visiting bees could be screened and also the choice of the types with variable pollen frequencies can be ascertained.

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TABLE 2 : Pollen morphology of the types recovered from the honey samples from Balurghat and Jalpaiguri

Name	Family	Pollen morphology			
		Aperture	Shape	Size (P. A. × E. D.)	Character
(1)	(2)	(3)	(4)	(5)	(6)
Aegle marmelos	Rutaceae	4-colporate	Oblate-spheroidal	14.0 × 16.0μm	Reticulate
Ageratum conyzoides	Asteraceae	3-colporate	Prolate	22.5 × 17.5μm	Echinate
Azadirachta indica	Meliaceae	4-colporate	Prolate-spheroidal	40.0 × 38.0μm	Punctitegillate
Blumea lacera	Asteraceae	3-colporate	Prolate-spheroidal	25.0 × 23.0μm	Echinate
Bombax ceiba	Bombacaceae	3-colporate	Peroblate	30.0 × 65.0μm	Reticulate
Borassus flabellifer	Arecaceae	1-sulcate	Oblate	16.0 × 26.0μm	Verrucate
Brassica juncea	Brassicaceae	3-colpate	Prolate	32.0 × 28.0μm	Reticulate
Cassia sophera	Caesalpiniaceae	3-colporate	Oblate-spheroidal	33.0 × 34.5μm	Punctitegillate
Casuarina equisetifolia	Casuarinaceae	3-pororate	Oblate	42.5 × 45.0μm	Psilate
Colocasia esculenta	Araceae	Inaperturate	Spheroidal	± 23.0μm in diam	With supratecta spinules
Coriandrum sativum	Apiaceae	3-colporate	Perprolate	42.0 × 20.0μm	Finely reticulate[1]
Croton bonplandianum	Euphorbiaceae	Inaperturate	Spheroidal	± 50.0μm in diam	Crotonoid pattern
Datura metel	Solanaceae	3-colporate	Oblate-spheroidal	42.0 × 45.5μm	Striatoreticulate
Desmodium sp.	Papilionaceae	3-colporate	Oblate	27.0 × 32.5μm	Reticulate
Holarrhena antidysenterica	Apocynaceae	3-5 porate	Oblate-sphoroidal	34.5 × 38.5μm	Rugulate
Hygrophila sp.	Acanthaceae	3-colporate with 3-pseudocolpa	Prolate-spheroidal	50.5 × 46.0μm	Reticulate
Leucas sp.	Lamiaceae	6-colpate	Prolate-spheroidal	25.5 × 24.0μm	Punctitegillate
Polygonum sp.	Polygonaceae	Pantoporate	Spheroidal	± 49.5μm in diam	Reticulate
Psidium guyava	Myrtaceae	3-colporate	Oblate	18.0 × 26.5μm	Punctitegillate
Solanum sp.	Solanaceae	3-colporate	Spheroidal	± 23.0μm	Punctitegillate
Vernonia cinerea	Asteraceae	3-colporate	Prolate	34.0 × 30.0μm	Echinate
Zizyphus jujuba	Rhamnaceae	3-colporate	Oblate	26.0 × 30.0μm	Psilate

P. A. = Polar axis ; E. D. = Equatorial diameter.

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Effect of farm-yard manure (FYM) on response to potassium by maize

Significant increase in dry-matter yield of maize by K application[1] and an increased uptake of K have been reported[2] when FYM was applied with potassium. It was reported[3] that field maize responded to K only when N and P were applied simultaneously. However, the uptake of K exceeded the amount of K applied to a maize crop[4]. Since maize is considered an exhaustive crop, emphasis has been laid on higher N and P supply, but K has been comparatively used less in India. Keeping this fact in view, the effect of organic matter and potassium was tested on the growth, yield and potassium contents of maize crop.

A field experiment was conducted in randomized block design with maize (*Zea mays* L. cv. *Manjari*) composite in *kharif* seasons of 1979 and 1980 on the alluvial soil of Banaras Hindu University farm. Individual and various treatment combinations of four levels of K (0, 25, 50 and 75 kg/ha as KCl designated as K_0, K_{25}, K_{50} and K_{75}, respectively) and two levels of FYM prepared at B. H. U. farm (0 and 20 metric tonnes/ha designated as FYM_0 and FYM_{20} respectively) were replicated three times making a total of 24 plots. Recommended common doses of N @ 120 kg N/ha as urea and P @ 30 kg P_2O_5/ha as single superphosphate were applied as basal dose to all the plots. The half of N and the whole of P were applied before sowing. The rest of N was applied in two equal splits near root after 30 days and at milk stage of the cobs.

The experimental soil was loam in texture and slightly alkaline in reaction (pH 7.5) with 0.36% of organic carbon. The available N, P and K were 198, 21 and 180 kg/ha respectively.

Plant and grain samples were digested in tri-acid mixture (HNO_3, H_2SO_4 and $HCLO_4$ as 10 : 1 : 4 *v/v*) and the extracts were analysed for potassium in a flame photometer[5].

The individual applications of K and FYM significantly increased the height of plant and cob length and the dry matter and grain yields with increasing levels of the treatment except the highest level of potassium which decreased all the parameters except plant height (Table 1). The plant height was maximum with FYM_{20} and the rest of the parameters were maximum with K_{50} treatment level The interaction effect of K × FYM was also positively significant on both the yield parameters and the combination K_{50} × FYM_{20} gave the maximum yield

TABLE 1 : Effect of K and FYM on growth, yield and K concentration of maize

Treatment	Plant height (cm)	Cob length (cm)	Dry-matter yield (Stover)'q/ha)	Grain yield (q/ha)	K concentration (%)	
					Stover	Grain
K_0	168.8	17.5	66.6	45.6	1.55	0.439
K_{25}	171.6	18.2	72.9	50 8	1.67	0 463
K_{50}	177.7	19 8	78.6	54.7	1.73	0.573
K_{75}	170.9	16.8	59.4	44.2	1.94	0.602
S. E. ±	1.12	0.21	0.43	0.41	0.02	0.012
C. D. at 5%	3.18	0.56	1.25	1.17	0.058	0.035
FYM_0	163.9	16.9	63.1	45.7	1.56	0.483
FYM_{20}	179.2	19.3	76.9	51.9	1.88	0.556
S. E. ±	0.75	0.14	0.31	0.29	0.014	0.009
C. D. at 5%	2.20	0.40	0.88	0.83	0.042	0.030

TABLE 2 : Interaction effect of K and FYM on yield and K concentration of maize

K level / FYM level	Stover				Grain			
	Yield (q/ha)		K concentration (%)		Yield (q/ha)		K concentration (%)	
	FYM_0	FYM_{20}	FYM_0	FYM_{20}	FYM_0	FYM_{20}	FYM_0	FYM_{20}
K_0	59.7	73.6	1.47	1.69	42.5	48.7	0.399	0.479
K_{25}	65.6	79.9	1.64	1.81	46.3	54.8	0.434	0.491
K_{50}	69.3	87.9	1.71	1.89	51.4	58.1	0.531	0.616
K_{75}	57.7	66.1	2.06	2.15	42.0	46.4	0.566	0.639
S. E. ±	0.62		0.029		0.58		0.018	
C. D. at 5%	1.78		0.085		1.66		N. S.	

values (Table 2). The depression in the yields brought about by maximum dose of K, individually or in treatment combination, might be due to its antagonistic effect with other cations[6].

Both K and FYM treatments individually increased significantly the K concentration of grain and stover with their increasing levels (Table 1). The K concentration in stover and grain was higher with K_{75} and FYM_{20} treatment levels separately and of them K_{75} gave the maximum value. The interaction effect of K × FYM on the K concentration in stover was significant but was nonsignificant in grain (Table 2). However, the treatment combination $K_{75} \times FYM_{20}$ gave the maximum K concentration in both of them. It was previously reported[7] that FYM had no effect on maize yields but was found to increase K concentration of both grain and straw.

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Effect of *Azolla* inoculation in checking the weeds under low-land rice

Azolla is a waterfern that fixs atmospheric nitrogen in association with the nitrogen-fixing blue-green alga—*Anabaena azollae*. Biological nitrogen fixation through *Azolla*—*Anabaena* complex is considered to be a potential biological system for increasing rice yield at comparatively low cost[2]. *Azolla* can be used effectively as a dual cropping with rice to supply nutrients after the formation of a mat either by decomposition after overgrowth or by incorporation into the soil[3]. Besides the nitrogen-fixing ability, *Azolla* has been reported to suppress weeds in rice fields[2,4]. The influence of *Azolla* inoculation on the suppression of *Echinochloa* spp. under flooded rice soil condition has been presently investigated.

A field experiment was conducted in randomized-blocks design with three replications during *Samba* season—1981-82. The rice variety Co.43 (TNAU-17005) was raised. *Azolla (A. pinnata)* was inoculated on 7th day after transplanting at different levels *viz.* 100, 150, 200, 250, 300, 350, 400, 450 and 500 g/m^2. No nitrogen fertilizer was applied to the inoculated plots. Potassium at 50 kg/ha was applied basally, while phosphorus was applied at 50 kg/ha in three split doses. Weeds were allowed to grow in all the treatments up to 40 days after planting and weeding was done on 40th day after planting. The weed flora comprising *Echinochloa glabrescens*, *E. stagmina*, *E. crusgalli* and *E. colonum* have been observed in the plots. Fresh weed weight of *Echinochloa* spp. in each treatment was recorded. First *Azolla* layer incorporated on 41 days after planting and second and third *Azolla* layers were incorporated subsequently at 21-day intervals. Grain yield was also recorded.

Significant reduction in weed growth was observed in plots inoculated with *Azolla* than uninoculated control. The weed growth was suppressed considerably at higher levels of *Azolla* inoculum (Table 1). Increase in *Azolla* inoculum proportionately decreased the weed growth. The suppression of *E. glabrascens*, *E. crusgalli*, *E. colonum* and *E. stagmina* was due to thick mat formation of *Azolla* layers which probably altered gas exchange, light penetration and temperature.

TABLE 1 : Effect of *Azolla* inoculation on suppression of weeds in lowland rice

Azolla inoculum (g/m²)	Fresh weed weight (kg/plot, 7.5 m²)	Per cent reduction over control	Grain yield (kg/ha)
100	2.89	46.87	6053
150	2.64	51.47	6306
200	1.80	66.91	6160
250	2.09	61.58	6000
300	2.16	60.29	6253
350	1.86	65.80	6106
400	1.40	74.26	5986
450	1.04	80.88	6493
500	1.29	76.28	6626
30 kg N/ha alone	5.70	—	5386
Uninoculated control	5.44	—	3413

C. D. = 1.250 C. D. = 1305
Significant at 1% level

Azolla inoculation at different inoculum levels significantly increased the grain yield. Janiya and Moody[1] reported that *Azolla* caused at 79.1% reduction in total weed weight 50 days after transplanting. Suppression of weeds by *Azolla* in wet-land rice was also reported by Lumpkin and Plucknett[4]. The present results are in conformity with the above findings.

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Record of some new predators of *Tetranychus neocaledonicus* Andre (Acarina : Tetranychidae) from India

The cucurbit mite, *Tetranychus neocaledonicus* Andre (Acarina : Tetranychidae), termed earlier as *T. cucurbitae* R. & S. and *T. equatorius* McGregor, has been recorded as a polyphagous pest, causing severe loss to many crops in India and abroad (catalogued by Prasad[1]). No specific attempt in the past was made to record the natural enemies of this mite species except by Gupta *et al.*[2] who recorded *Amblyseius hibisci* Chant feeding upon this species infesting cotton crop.

During an ecological investigation of *T. neocaledonicus*, which is a serious pest of cucurbits in Rajasthan, an attempt was made to search for the natural enemies of the pest throughout the year. Eight predators belonging to two families, *viz.* Coccinellidae (Coleoptera) and Phytoseiidae (Acarina) were found predating upon the species and are listed in Table 1. These predators are reported for the first time feeding on *T. neocaledonicus* infesting cucurbits in India. However, some of these predators have been recorded feeding also on other species of mites belonging to family Tetranychidae[2-4]. But it must be mentioned that the populations of these predators remained low throughout their active season and did not

TABLE 1 : Predators of *T. neocaledonicus* Andre

Species	Active Season
Family : Coccinellidae	
Menochilus sexmaculatus Fabr.	May-June
Brumus sataralis Fabr.	May-June, October
Illies cincta Fabr.	June-July
Rodolia sp.	May-June
Stethorus sp.	June-October
Chilocores sp.	May-June, October
Family : Phytoseiidae	
Amblyseius sp.	May-June, October
Phytoseius sp.	May, September-October

play an effective role in reducing pest population. No parasite species of *T. neocaledonicus* was recorded.

The authors are thankful to the Director, Zoological Svrvey of India, Calcutta for identification of the predators.

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Leaf rust of *Cymbopogon jawarancusa*

A new leaf-spot disease was observed on the plants of *Cymbopogon jawarancusa* (Jones) Schultz in the experimental farm of our laboratory during July, 1981. The disease appeared again in July, 1982 and 1983 as long narrow, elliptical blisters, parallel to the long axis of leaf. The pathogen was found to be associated with the formation of lesions on the leaves which later turned brown. Pustules developed during July on the dorsal surface of the infected leaves, which in the beginning were yellow and later turned black, Pustule size varied from 8.5×0.5 mm to 1.6×0.25 mm.

Microscopic examination of the fungus revealed it as *Puccinia* species. The mycelium was colourless branched and septate. The aecium was found on the upper surface of the leaf which liberated aeciospores after the rupture of epidermis. The aeciospores were in chains, angularly globose, smooth-walled and yellowish grey in colour. They measured 16.2-19.8 μm in diameter with 2-4 germpores per sporewall. The uredospores were oval, stalked, reddish brown in colour and measured 26.1-22.5×19.8-20.7 μm.

Late in July, teleutospores were observed on the same infected leaves. Telia were subepidermal containing teliospores borne singly on pedicels. Length of stalk varied from 18 to 45 μm. Teleutospore was 2-celled, with brown wall, measuring 33.3-36.9 μm and 18.9-24.3 μm respectively Each teleutospore showed one germpore per cell. The fungus was identified as *Puccinia cesatii* Schreet. The voucher specimen was deposited in Ajrekar Mycological Herbarium, Maharashtra (AMH-5118).

A survey of literature showed that this fungus was first reported from India on *Bothriocola* spp[1]. Therefore, this is the first report of rust disease on *C. jawarancusa*. The disease was prevalent under dry conditions. However, the plants after harvest, did not show any symptoms of disease on regrowth.

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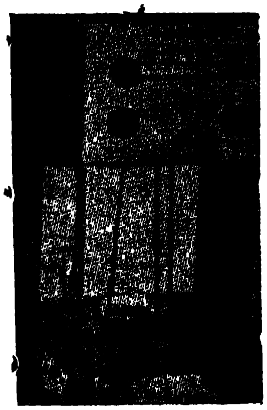

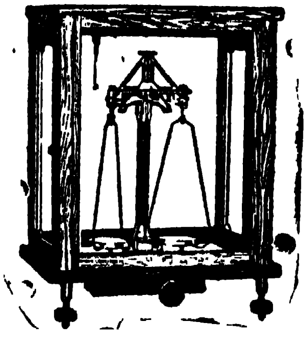

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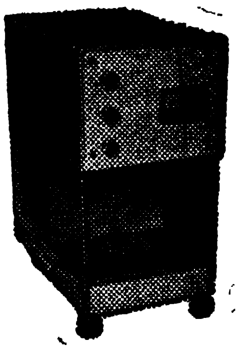

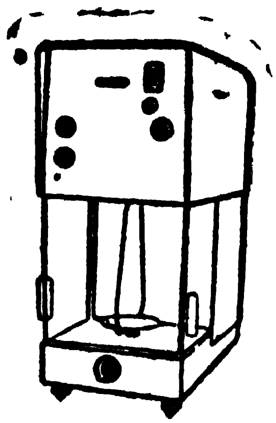

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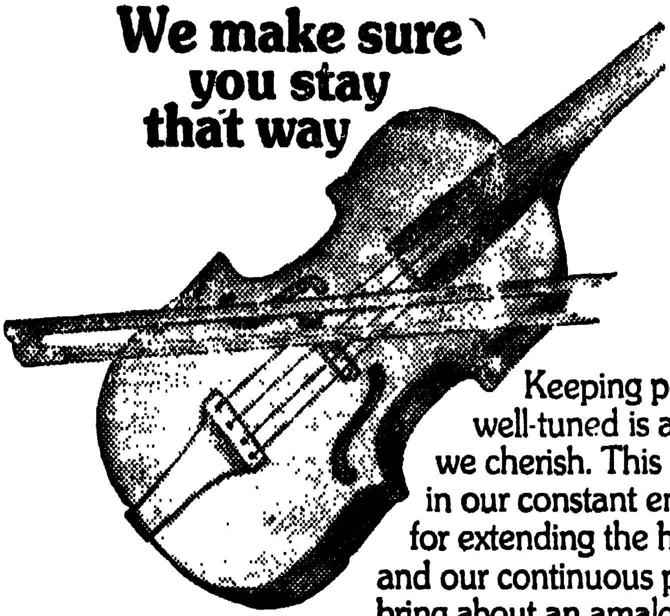

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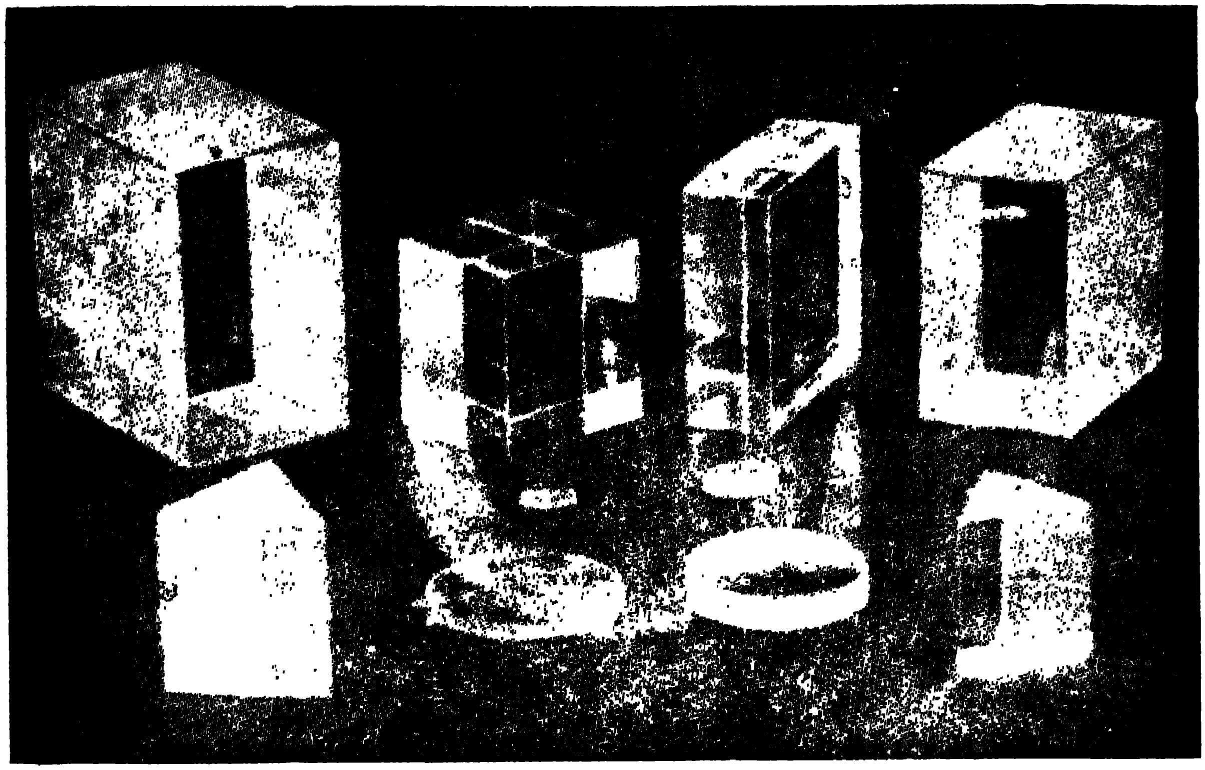

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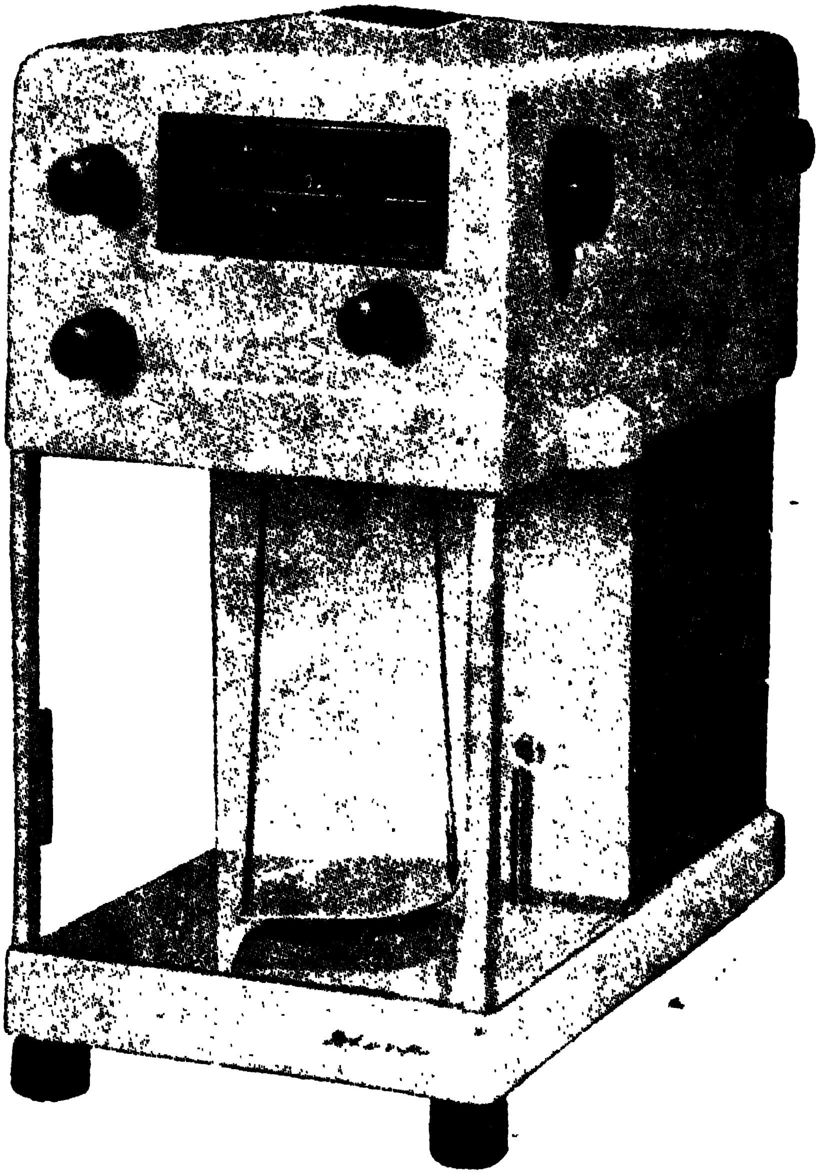

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CONSTITUENTS OF *AZADIRACHTA INDICA* AND *MELIA AZEDARACH*

by

S. B. MAHATO N. P. SAHU and G. PODDER

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CONSTITUENTS OF *AZADIRACHTA INDICA* AND *MELIA AZEDARACH*

S. B. MAHATO*, N. P. SAHU* and G. PODDER**

Constituents of *Azadirachta indica* and *Melia azedarach* are reviewed. The techniques of isolation, structure elucidation and structural features of tetranortriterpenoids isolated from the two plants are discussed. A compilation of the constituents, along with available physical and spectroscopic (UV, IR, ^{1}H and ^{13}C NMR data), is included. The biological activities of the compounds are also reviewed.

Azadirachta indica A. Juss, (Syn. *Melia azadirachta*) and *Melia azedarach* Linn. are the two closely related species of the Meliaceae. The former is popularly known as the Indian neem or the Indian lilac and the latter as the Persian lilac. The extensive uses of both the plants for the treatment of a variety of human diseases are reminiscent of broad-spectrum activities of some modern medicines. The present review is concerned with the recent development in the isolation and structure elucidation of various constituents particularly limonoids of the two species, compilation of physical and spectral (UV, IR, ^{1}H and ^{13}C NMR) data and biological activity reported up to mid-1984.

A. indica is an evergreen tree which grows wild in almost all the dry forests of India. Almost every part of this plant has been used in the folk medicine in India from antiquity. The bark is regarded as tonic, astringent and useful in fever, vomiting and skin diseases. The leaves are reputed to be useful in skin diseases and the fruits are described as purgative and emolient and are useful in the treatment of intestinal worms, urinary diseases and piles. The dry flowers are used as tonic[1]. The water soluble fraction of the alcoholic extract of the green leaves has been found to possess significant hypoglycemic property[2,3].

M. azedarach is native of West Asia and now naturalised throughout the warm countries[4] including Africa, Australia and Americas[5,6]. The various parts of the tree have been reported to possess similar therapeutic values as those of *A. indica*. The juice of the leaves is said to be anthelmintic and emmenagogue. The root is useful in the treatment of tumours, pain in the heart, leucoderma and blood impurities. The leaves and bark are used internally and externally in leprosy and scrofula[1]. In Mauritius and China extracts of the bark are used as antihelmintic. In South Africa the plant is used for the treatment of leprosy, eczema and the relief of asthmatic attacks.

The Constituents

The earlier chemical work on different parts of these two plants are contradictory and inconclusive. In most cases, the consti-

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tuents isolated are impure and the chemical structures have not been established. Both the species are noteworthy for containing tetranortriterpenoids or the limonoids of varied structural features. The classical era in the chemistry of limonoids ended with the structure elucidation of limonin from citrus seeds in 1960 both by chemical *cum* spectroscopic[7] and X-ray crystallographic[8] methods. Since then, many limonoids have been isolated and characterised from the plants of the two families, Meliaceae and Rutaceae including *A. indica* and *M azedarach* which are widely distributed species of the former. The literature on the two plants which have been accumulated are scattered, although these have been covered partially in a few reviews[9-12].

(a) *Isolation :* Chromatographic techniques, e.g. column chromatography (CC), thin-layer chromatography (TLC), 'preparative-layer chromatography (PLC) and high-performance liquid chromatography (HPLC) have extensively been used for the isolation of the constituents. Before subjecting to chromatography, the plant extractive (often EtOH extract) is fractionated by solvent partition for initial separation of the constituents depending upon the difference of polarities. Treatment with acid or base or application of excessive heat very often leads to the isolation of artifacts. Azadirachtin(2), a highly oxygenated and complex tetranortriterpenoid was isolated from the fruits of *Azadirachta indica*[13] and *Melia azedarach*[14] first by solvent partition of the EtOH extract followed by CC on floridin earth or PLC on kieselgel layers. The homogenous fractions were combined and converted to bis-(trimethylsilyl)-azadirachtin and then subjected to PLC for further purification. Ohchinolide A(51), B(52), nimbolidin A(42), B(43), nombolinin B(46) and 1-desacetyl nimbolinin B(12) have successfully been isolated from the petroleum-ether and ether-extracts of the fruits of *M. azedarach* by CC on kieselgel followed by reversed-phase HPLC on RP-18 column using methanol : water (7 : 3) as mobile phase and also on Lichroprep Si 60 column using methylene chloride-ethyl acetate as mobile phase[15]. Meliatoxins A$_1$(29), A$_2$(30), B$_1$(31) and B$_2$(32) which were very sensitive to traces of acid and decomposed on attempted TLC purification on silica were isolated from ether soluble fraction of the EtOH extract of *M. azedarach* fruit by successive CC on silicic acid and micronized XAD-2 resin followed by medium-pressure liquid chromatography (MPTLC) on Lichroprep Si 60 and HPLC on μ Bondapak C$_{18}$ column[16]. The method of adsorbing the EtOH extract of the fresh leaves of *A. indica* on paper pulp followed by successive extraction with chloroform, ethylacetate, acetone and methanol and chromatographic purification (CC and PLC) of each extract was found to be useful for separation of flavanoid and limonoid constituents[17]

(b) *Structure elucidation :* The combination of various spectroscopic methods, e.g., UV, IR, ^{1}H NMR, ^{13}C NMR, Mass, ORD and CD is now the most valuable arsenal for the determination of the structures of natural products including limonoids. Single-crystal X-ray crystallographic method has also been applied for the determination of complete structure and stereochemistry of a few complex limonoids isolated from *A. indica* and *M. azedarach.* The structure of azadirachtin(2) has been determined by the application of partially relaxed Fourier transform (PRFT) and continuous wave decoupling (CWD) ^{13}C NMR technique and extensive usage of solvent effects, e.g. addition of C$_6$D$_6$ to CDCl$_3$, addition of Eu(fod)$_3$ and consideration of ^{13}C NMR patterns[18]. The structures of complex limonoids[19,20], e.g., sendanin(56) and desacetylsendanin were established by IR, MS, ^{1}H and ^{13}C NMR measurements. ^{13}C NMR data of a number of limonoids are available (Tables 1-4) and it becomes a comparatively easy task to determine the structure of a new limonoid by comparison of its ^{13}C values with those of reported data and considering the known chemical shift rules and substituent effects.

TABLE 1 : ^{13}C NMR data of ohchinolide-A(51), ohchinolide-B(52), nimbolidine-A(42), nimbolidine-B(43), nimbolinin-B(46), 1-desacetylnimbolinin-B(12), salannin(53) and azadirachtin(2)[15, 18, 65]

C-Atom	(51)	(52)	(42)	(43)	(46)	(12)	(53)	(2)
1	71.5	71.7	71.6	71.7	71.6	71 5	72.6	70.5
2	27.6	27.6	27.4	27.3	28 0	29.5	27 5	29.4
3	71.8	71.8	72 0	71.9	72.0	72.9	71 3	67 0
4	42.5	42.4	42.8	42.7	42.8	42.7	42 7	45.4
5	40.7	40.6	40.4	40.3	40.5	39.6	40 0	37.1
6	72.0	71.8	73.1	72.9	72.6	72.9	71.3	74.4
7	75.2	75.6	76.3	75.6	75.0	75.1	85 6	76 4
8	45.3	45.1	47.5	47.4	45.8	45.7	49.1	50.2
9	37.2	37.0	38.8	38.8	35.8 38.4	36.3	39.4	44.7
10	40.3	40.1	40.9	40.8	40.8	41 3	40.6	52.5
11	32 6	32.5	32.1	32.0	32.3 34.6	31.6	30 7	104.1
12	171.1	171.2	173.5	173.6	91.6 99.2	92 0	172 7	169 5
13	138.5	138.4	133.2	133.4	141.0 141.5	142.6	134.8	69.9
14	148.0	147.9	148.9	148.6	143.6	143.3	146.4	68.5
15	85.8	85.9	82.3	82.2	77.4 81.9	77.9	87.7	73.8
16	37.5	37.7	37.0	37.1	38.6	38.5	41.4	25.1
17	47.0	47.1	47.7	47.7	46.8	47.1	49.4	48.7
18	16.1	16.0	17.6	17.5	16.1	16.5	15.1	20 9
19	15.4	15.4	16.0	16.0	16.2	16.3	16.9	18.4
20	126.5	126.5	127.7	128.0	129.0	128.9	127.0	83 5
21	139.2	139.2	139.2	139.5	139.3	139.4	138.7	107.3
22	110.0	110.0	109.7	110.2	110.8	110.9	110.5	108 7
23	143.3	143.4	143.0	142.9	143.0	143.0	142.8	147.0
28	78.2	78.0	78.2	78.0	78.1	78.1	77.6	73.0
29	19.2	19.2	19.7	19.8	19.5	19.0	19.6	166.1
30	20.2	20.1	20.1	20.2	20.8	20.8	13.0	69.1
$COOCH_3$	—	—	52.0	52.0	—	—	51.2	53.5 52.7
$OCO\underline{C}H_3$	21.1	21.0	21.6	21.6	21.0	21.2	20 0	—
	20.8	20.1	21.4	21.3	21.7	—	—	—
	—	—	21.0	20.9	—	—	—	21.3
$O\underline{C}OCH_3$	169.6	169.6	171.0	171.0	170.6	170.6	170.2	173.2
	160.1	169.1	169.9	169.9	170.1	—	—	—
	—	—	169.6	169.6	—	—	—	—

TABLE 1 (Continued)

C-Atom	(51)	(52)	(42)	(43)	(46)	(12)	(53)	(2)
	[OB_z]	[OT_g]	[OB_z]	[OT_g]	[OT_g]	[OT_g]	[OT_g]	[OT_g]
	130.4	166.0	131.1	166.6	166.5	166.9	166.2	171.1
	129.2	128.6	127.8	129.4	129.3	129.3	129.0	137.6
	128.6	137.2	128.0	136.3	136.7	136.9	137.1	128.6
	133.4	14.5	132.7	14.4	14.4	14.6	11.4	14.3
	128.6	12.1	128.0	12.4	12.2	12.4	14.3	11.9
	129.2		127.8					
	164.4		165.2					

TABLE 2 : ^{13}C NMR data of 1α-methoxy-1, 2-dihydroepoxyazadiradione(33), 1β, 2β-diepoxyazadiradione(14), 7-acetylneotrichilenone(1), azadiradion(3), 17-epiazadiradione(16), 17β-hydroxyazadiradione(19), 3-desacetylsalannin(6) and salannol(54)[22, 48, 50, 53]

C-Atom	(33)	(14)	(1)	(3)	(16)	(19)	(6)	(54)
1	82.6	63.1	157.8	156.8	156.7	157.1	72.7	72.5
2	37.2	56.7	126.0	125.8	125.7	125.8	30.4	30.9
3	213.9	211.2	204.4	203.9	203.8	204.1	70.7	70.9
4	47.0	44.3	44.1	44.0	44.0	44.1	44.1	44.2
5	41.5	38.5	45.1	38.2	38.0	38.8	38.7	38.9
6	24.2	23.9	22.3	23.4	23.5	22.4	72.3	72.5
7	74.0	73.6	73.4	73.8	74.0	74.2	85.8	85.9
8	42.9	42.7	41.1	44.5	44.7	44.8	48.9	48.9
9	35.3	38.9	47.1	46.1	46.1	46.0	39.4	39.4
10	41.8	38.7	39.6	39.9	39.9	39.9	40.9	40.7
11	15.8	16.5	17.7	15.7	15.5	15.9	30.4	30.0
12	28.8	28.5	34.4	30.3	26.0	23.5	172.5	173.0
13	42.2	42.7	42.2	47.9	47.5	50.4	134.7	134.8
14	72.9	72.7	61.3	192.3	195.1	193.4	146.5	146.5
15	57.5	57.7	218.6	123.2	121.3	120.3	87.8	87.9
16	208.8	208.5	43.2	204.9	207.4	205.8	41.2	41.1
17	50.9	50.9	38.0	60.7	59.6	80.7	49.3	49.5

TABLE 2 (Continued)

C-Atom	(33)	(14)	(1)	(3)	(16)	(19)	(6)	(54)
18	24.8	27.4	27.9	26.4	31.7	30.8	13.0	12.9
19	16.3	15.9	19.3	18.9	18.9	19.1	15.1	15.5
20	116.9	116.6	122.9	118.4	123.6	122.6	127.0	127.2
21	141.6	141.7	140.3	142.7	143.0	142.6	138.6	138.9
22	111.1	111.0	110.8	111.1	110.0	109.6	110.5	110.9
23	142.3	142.5	143.0	141.6	140.3	141.4	142.7	142.9
28	23.6	24.2	27.4	21.2	21.2	21.2	77.7	77.9
29	20.9	20.6	21.1	26.9	26.9	27.0	19.8	19.8
30	19.4	19.5	18.2	26.2	20.9	25.1	16.8	16.9
$CH_3\underline{C}O$	170.0	170.0	169.3	169.5	169.5	169.7	—	—
$\underline{C}H_3CO$	21.3	21 3	21.1	20.9	20.8	21.0	—	—
$\underline{C}H_3O$	56.8	—	—	—	—	—	—	—
$COO\underline{C}H_3$	—	—	—	—	—	—	51.3	51.5
OT_g 1'	—	—	—	—	—	—	166 2	171.9
2'	—	—	—	—	—	—	128.6	43.5
3'	—	—	—	—	—	—	137.7	25.4
4'	—	—	—	—	—	—	12.1	22.7
5'	—	—	—	—	—	—	14.4	22.6

TABLE 3: ^{13}C NMR data of nimbinene(39), 6-desacetylnimbinene(11), nimbandiol(35), 6-0-acetylnimbandiol(5), 4 α, 6 α-dihydroxy A-homoazadirone(15), sendanin(56), gedunin(18) and 1, 3-diacetylvilasinine(13)[12, 49, 50, 53, 57].

C-Atom	(39)	(11)	(35)	(5)	(15)	(56)	(18)	(13)
1	212.3	213.2	202.5	201.8	154.3	70.1	156.8	72.3
2	39.9	40.1	124.7	124.4	128.9	36.6	125.6	27.7
3	126 2	119.2	151.9	151.3	199.9	74.0	203 5	71.7
4	136.9	139.0	70.9	70.1	75.0	39.8	43.8	42.3
5	43.2	47.4	50.2	48.3	53.7	29 0	45.8	39.6
6	69.2	66.5	67.3	70.7	68.5	26.5	27.0	72.9
7	85.2	86.5	87.4	84.8	78.6	69.5	73.1	74.0
8	47.9	47.4	47.9	48 5	43.9	42.2	42.5	45.8
9	37.0	37.3	38.7	38.7	39.7	49.8	39.8	33.6

TABLE 3 (Continued)

C-Atom	(39)	(11)	(35)	(5)	(15)	(56)	(18)	(13)
10	49.5	49.7	47.6	48.1	42.2	43.2	39.8	39.2
11	35.5	33.7	34.0	34.1	18.5	208.7	14.7	15.2
12	173.6	173.7	173.5	173.4	34.1	79.1	25.8	33.0
13	135.2	134.9	135.0	135.4	46.7	46.5	38.5	47.4
14	146.5	147.4	146.5	145.9	158.0	73.2	69.6	159.9
15	86.9	88.2	86.8	87.3	120.5	59.1	56.6	120.7
16	41.4	41.4	41.3	41.4	34.5	34.2	167.2	34.3
17	49.6	49.5	49.6	49.6	51.8	39.2	78.1	51.9
18	12.8	12.9	12.7	12.8	22.2	20.7	26.9	21.2
19	21.6	21.8	17.4	17 2	15.0	66.0	20.9	26.2
20	126.9	126.9	126.7	126.8	124.2	124.0	120.3	124.5
21	139.0	138.8	138 9	139.0	139.7	143.2	142.8	139 8
22	110.5	110.5	110.4	110.5	110.8	112.8	109.7	111.1
23	143.1	143.2	142.9	143.1	142.7	141.6	141.0	142.6
28	—	—	—	—	58 0	19.2	18.0	77.9
29	14.3	14.1	23.5	23.9	27.3	95.6	19.4	15.4
30	17.1	17.5	15.8	15.7	26.4	15.7	17.5	19.5
COO$\underline{C}H_3$	51.7	51.7	51.5	51.6	—	—	—	—
O$\underline{C}OCH_3$	170.7	—	—	169.8	172.5	170.9x2	169.5	170.3
	—	—	—	—	—	170.0	—	170.0
OCO$\underline{C}H_3$	21.1	—	—	21.6	21.6	22.8	20.7	21.2
						21.1		21.1
						20.7		

TABLE 4 : ^{13}C NMR data of 7-desacetyl-7-benzoylazadiradione(7), 7-desacetyl-7-benzoylepoxyazadiradione(8), 7-desacetyl-7-benzoylgedunin(9), ohchinolal(50), ohchinin(48), ohchinal(47), ohchininacetate(49) and sendanal(55)$^{23, 93, 83, 86}$.

C-Atom	(7)	(8)	(9)	(50)	(48)	(47)	(49)	(55)
1	156.7	157.6	157.0	75.2	73.4	72.1	71.7	70.5
2	125.8	125.9	126.0	28.5	30.7	28.2	27.7	28.1
3	203.6	204.1	203.8	76.5	72.7	72.7	72.6	76.1
4	43.9	44.4	44.0	47.2	44.4	42.9	42.7	47.8

TABLE 4 (Continued)

C-Atom	(7)	(8)	(9)	(50)	(48)	(47)	(49)	(55)
5	46.5	47.4	46.6	35.2	39.7	40.2	39.9	37.3
6	23.6	25.0	23.7	69.1	71.1	71.3	71.3	67.6
7	74.0	73.6	73.2	86.2	86 3	85.8	85.8	75.0
8	44.6	43.5	43.0	49.2	49.2	48.7	49.1	43.8
9	38.5	40.1	39.8	39.7	39.1	38.3	39.5	35.5
10	40.0	39.9	40.2	42.3	41.2	40.9	40.7	41.6
11	15.8	16.2	16.1	30.4	30.8	40.7	30.7	24.4
12	30 0	28.8	25 9	172.6	172.8	199.1	172.6	77.4
13	48.0	42.7	38.8	135.7	134.6	136.9	134.9	51.5
14	191.7	72.5	69.5	146.4	146.7	145.1	146.4	158.8
15	123.3	57.8	57.1	87.7	88.2	88.1	88.0	122.5
16	204.6	207.9	166.7	41.3	41.3	41.8	41.3	36.8
17	60.4	50.7	78.0	49.8	49.7	49.7	49.4	50.3
18	26.5	27.3	19.8	13.0	15.4	15.4	15.2	14.6
19	18.8	19.9	18.7	16.9	17.0	16.9	16.9	15.6
20	118.3	116.5	120.4	127.2	127.3	126.6	126.9	124.3
21	141.5	141.6	141.2	139.1	138.9	138.3	138.6	142.1
22	111.1	111.0	109.9	110.8	110.9	109.7	110.4	111.7
23	142.5	142.4	143.0	143.1	143.0	143.2	142.8	140.3
28	26.9	25.0	27.3	206.9	78.1	77.9	77.6	203.9
29	21.1	21.0	21.2	14.0	20.0	19.7	19.6	16.8
30	26.5	19 9	18.0	17.1	13.2	13.4	13.0	27.8
$\underline{C}H_3CO$	—	—	—	51.5	51.6	—	—	—
$CO_2\underline{C}H_3$	—	—	—	—	—	—	51 5	—
$OCO\underline{C}H_3$	—	—	—	20.8	—	21.0	21.1	21.3X2
$O\underline{C}OCH_3$	—	—	—	170.4	—	170.4	170.3	168.6
$OCOCH_3$	—	—	—	—	—	—	—	170.8
	$[OB_z]$	$[OB_z]$	$[OB_z]$	$[OT_g]$	$[OC_{in}]$	$[OB_z]$	$[OC_{in}]$	
	129.6	130.0	129.7	166.4	165.7	165.0	165.4	—
	129.2	129.5	129.3	128.7	118.3	129.7	118.7	—
	128.4	128.7	128.7	143.1	145.6	129.7	144.6	—
	133.1	133.4	133.5	12.1	135.1	128.7	134.3	—
	128.4	128.7	128.7	14.5	128.4	133.7	127.9	—
	129.2	129.5	129.3	—	129.2	—	129.0	—
	164.9	165.7	165.7	—	130.7	—	130.3	—

TABLE 5 : Constituents of *A. indica* and *M. azedarach*

Compound (Structure), Source, M. Formula, mp, [α]D (CHCL$_3$) ★	UV (nm) IR (cm^{-1})	^{1}H NMR (MHz), δ
1	2	3
7-Acetylneotrichilenone(1)[29], Ai-s, $C_{28}H_{36}O_{5}$, 208°, —21°	3140, 1745, 1735, 1675, 1250, 1030, 875	(360), 7.40 (m, H-21), 7.31 (m, H-23), 7.17 (d, 10.4, H-1), 6.30 (m, H-22), 5.89 (m, H-2), 4.96 (t, H-7), 3.50 (t, H-17), 2.51 (d, 10, H-16), 2.44 (H-14), 2.10 (—OAc), 2.13-2 0 (m, H-5), 1.95-1.84 (m, H-6), 1.83-1.78 (m, H-11), 1.43-1.36 (m, H-9), 1.35-1.29 & 2.07-2 0 (m, H-12), 1.16 (H-30), 1.14 (H-19), 1.08 (H-29), 1.06 (H-28), 0.78 (H-18)
Azadirachtin (2),[1] Ai-I, $C_{35}H_{44}O_{16}$, 154-158°	217 ; 3410, 1745, 1720, 1700, 1645, 1620, 843	(100), 6.42 (d, 2.5, H-23), 5.64 (H-21), 5.49 (t, H-3), 5.05 (d, 2.5, H-22), 4.76 (t, H-1), 4.70 (d, 2.5, H-15), 4.62 (d, 3, H-7), 4.58 (dd, 3, 12, H-6), 3.35 (d, 12, H-5), 3.65/4.16 (H-30), 3.34 (H-9), 2.38 (d, 6, H-17), 2.30 (m, H-2), 2.06 (H-18), 1.92 (OAc), 1.72 (H-19), 1.70 (ddd, H-16), 1.31 (d, 12, H'-16), 3.75/4.05 (H-28) ; 6.85 (m), 1.84, 1.78 (d) (Tigloyl)
Azadiradione (3),[47] Ai-s $C_{28}H_{34}O_{5}$, 168°, —24°	225 (ε, 14,800) ; 3150, 1739, 1710, 1680, 886	7.45, 6.28 (furan) ; 7.17 (d, 10, H 1), 5.85 (t, H-15), 5.83 (d, 10, H-2), 5.32 (t, H-7), 3.43 (H-17), 1.95 (OAc) ; 1.35, 1.27, 1.08, 1.03 (methyls)
Azadirone (4),[47,48] Ai-s, $C_{28}H_{36}O_{4}$, Amorphous, +26°	225 (ε, 10,000) ; 1740, 1680, 1245, 886	7.35, 7.25, 6.30 (furan ; 7.18 (d, 10, H-1), 5.83 (d, 10, H-2), 5.35 (t, H-7), 5.24 (t, H-15), 1.97 (OAc) ; 0.81, 1.10, 1.20, 1.23 (5 methyls)

TABLE 5 (Continued)

1	2	3
6-0-Acetylnimbandiol (5),[4] Ai-l,o,b, $C_{28}H_{34}O_{8}$, 178°, +245°	3440, 3120, 1740, 1735, 1665, 1500, 1260, 1125, 1035, 870	(300), 7.33 (m, H-21), 7.23 (m, H-23), 6.50 (d, 10, H-3), 6.30 (m, H-22), 5.79 (d, 10, H-2), 5.55 (dddq, 7, 7, 1.8, H-15), 5.47 (dd, 12, 5, 3, H-6), 4.08 (d, 3, H-7), 3.66 (d, 8, H-17), 3.64 ($COOCH_3$), 3.30, (OH), 3.07 (d, 12, 5, H-5), 2.90 (dd, 16, 6, H-11), 2.79 (t, 6, H-9), 2.22 (dd, 16, 6, H'-11), 2.22 (OAc), 2.21 (dd, 12, 7, H 16), 2.05 (ddd, 8, 7, 12, H-16), 1.68 (d, 1, 7, H-18), 1.39 (H-29), 1.37 (H-30), 1.25 (H-19)
3-Desacetylsalannin(6)[10], Ai-o, $C_{32}H_{42}O_{8}$, 214-215°, +13.4°	3405, 3120, 1725, 1710, 1650, 1500, 1265, 1075, 1055, 1040, 920, 875	7.3 (m, H-21), 7.23 (m, H-23), 6.27 (m, H-22), 5.36 (dddq, 1.7, 1, 7, 7, H-15), 5.0 (t, 3, H-1), 4.17 (d, 3, H-7), 4.12 (d, 7, H-28), 3.99 (dd, 3, 12.5, H-6), 3.86 (d, 3, H-3), 3.60 (dbr, 8, 1, H-17), 3.61 (d, 7, H'-28), 2.71 (d, 12.5, H-5), 2.62 (dd, 3.5, 9.5, H-9), 2.25 (dt, 3, 16, H-2), 2.14 (dd, 3.5, 16, H-11), 2.22 (dd, 7, 1, 12, H-16), 2.30 (dd, 9.5, 16, H'-11), 2.11 (ddd, 8, 7, 12, H'-16), 2.05 (dt, 3, 12, H'-2), 1.65 (d, 1.7, H-18), 1.31 (H-30), 1.15 (H-29), 0.95 (H-19) ; 6.88 (qq, 7, 1), 1.90 (dq, 1, 1), 1.83 (dq, 7, 1) (tigloyl) ; 3.18 ($COOCH_3$), 2.40 (OH)
7-Desacetyl-7-benzoyl-azadiradione (7)[11], Ai-s, $C_{31}H_{36}O_{5}$, Amorphous, +38.8°	232 (ε, 30, 210) ; 3130, 3030, 1710, 1700, 1670, 1275, 1110, 1030, 710	(90), 7.51-7.28 (part benzoyl moiety, H-21, H-23), 7.18 (d 10, H-1), 6.19 (m, H-22), 5.93 (H-15), 5.90 (d, 10, H-2), 5.62, (m, H-7) 3.40 (H-17), 2.84-1.55 (m, H-5, H-6, H-9, H-11, H-12), 1.42 (H-30), 1.31 (H-19), 1.11 (H-29), 1.04 (H-28), 1.0 (H-18) ; 8.0-7.54 (m, benzoyl)

TABLE 5 (Continued)

1	2	3
7-Desacetyl-7-benzoyl-epoxyazadiradione(8)[22] Ai-s, $C_{33}H_{36}O_6$, Amorphous, +81.4°	228 (ε, 26,000); 3140, 3030, 1755, 1670, 1275, 1105, 1030, 718	(360), 7.40 (m, H-21), 7.33 (m, H-23), 7.23 (d, 10, H-1), 6.11 (m, H-22), 5.92 (d, 10, H-2), 5.13 (m, H-7), 3.83 (H-17), 3.56 (H-15), 2.81 (H-9), 2.41 (m, H-5), 2.20-1.75 (m, H-6, H-11, H-12), 1.31 (H-30), 1.29 (H-19), 1.09 (H-29), 1.01 (H-28), 0.92 (H-18); 7.93 (m), 7.57 (m), 7.42 (m) (benzoyl)
7-Desacetyl-7-benzoyl-gedunin(9)[22], Ai-s, $C_{33}H_{36}O_7$, 278°, +105°	230 (ε, 24,000); 3140, 3030, 1745, 1715, 1670, 1275, 1200, 1105, 1100, 1030, 720	7.39 (m, H-21), 7.38 (m, H-23), 7.17 (d, 10, H-1), 6.79 (m, H-22), 5.89 (d, 10, H-2), 5.58 (H-17), 4.91 (m, H-7), 3.70 (H-15), 2.66 (m, H-9), 2.34 (m, H-5), 2.0-1.56 (m, H-6, H-11, H-12), 1.27 (H-30), 1.23 (H-19), 1.21 (H-29), 1.07 (H-28), 0.96 (H-18); 7.98 (m), 7.58 (m), 7.45 (m) (benzoyl)
Desacetylnimbin (10)[15] Ai-s, $C_{28}H_{34}O_8$, 208-210°, +110°	Not reported	Not reported
6-Desacetylnimbin-ene (11)[40], Ai-l, s, b, $C_{26}H_{32}O_6$, 141°, +132°	3500, 3110, 1740, 1705, 1500, 1260, 1060, 880	(360), 7.32 (m, H-21), 7.21 (m, H-23), 6.27 (m, H-22), 5.57 (dddt, 1, 5.6, 3, 1, H-3), 5.44 (dddq, 6.8, 7, 1, 1.6, H-15), 4.03 (d, 3.5, H-7), 4.00 (dd, 12.5, 3.5, H-6), 3.66 (d, 1, H-17), 3.57 ($COOCH_3$), 2.97 (dddt, 3, 1.8, 1, 19.4, H-2), 2.86 (dddt, 19.4, 5.6, 0.8, 1, H'-2), 2.91 (d, 12.5, H-5), 2.79 (dd, 16, 5.8, H-11), 2.64 (dd, 5.8, 4.4, H-9), 2.22 (dd, 16, 4.4, H-11), 216 (dd, 11.8, 6.8, H-16), 2.04 (dd, 7, 8.2, H'-16), 2.04 (H-29), 1.67 (d, 1.6, H-18), 1.30 (H-30), 1.04 (H-19)

TABLE 5 (Continued)

1	2	3
1-Desacetylnimbolinine-B (12)[15], Ma-f, $C_{32}H_{44}O_9$, Amorphous, —42°	3420, 1725, 1260, 1160, 1050, 880	7.3 (m, H-21), 7.23 (m, H-23), 6.37 (m, H-22), 5.74 (d, 3, H-7), 5.13-5.38 (m, H-12), 5.17 (d, 8, H-15), 4.95 (t, 3, H-3), 4.12 (dd, 12.5, 3, H-6), 3.77-3.82 (m, H'-12), 3.61-3.67 (m, H-1), 3.5 (H-28), 3.27 (d, 9, H-17), 3.1 (dd, 7.5, 2.5, H-9), 2.76 (d, 12.5, H-5), 2.26 (m, H-11), 2.26 (ddd, 14, H-16), 2.17-2.22 (m, H-2), 2.05 (m, H-1 1), 2.05 (OAc), 1.78 (H-18), 1.55 (d, 14, H'-16), 1.47 (H-30), 1.16 (H-29), 0.93 (H-19), 3.86-3.93 (m, OH), 1.88 (d, 1), 1.80 (d, 7), 6.89 (qq, 7, 1)
1,3 -Diacetylvilasinine (13)[50], Ai-o, $C_{30}H_{40}O_7$, 157-158°, —6.5°	3510, 3100, 1735, 1725, 1500, 1255, 1240, 1050, 1035, 875	7.36 (m, H-21), 7.24 (m, H-23), 6.27 (m, H-22), 5.61 (dd, 1.5, 3.5, H-15), 4.91 (t, 3, H-3), 4.67 (t, 3, H-1), 4.18 (d, 3, H-7), 4.14 (dd, 3, 12.5, H-6), 3.59 (d, 7, H-28), 3.56 (d, 7, H'-28) 2.83 (dd, 11.5, 7.5, H-17), 2.67 (d, 12.5, H-5), 2.56 (ddd, 16, 1.5 11.5, H-16), 2.56 (m, H-9), 2.40 (ddd, 16, 3.5, 7.5, H'-16), 2.19 (dt, 16, 3, H-2), 2.08 (dt, 16, 3, H'-2), 1.71-1.8 (m, H-12) 1.50-1.59 (m H-11. H'-12), 1.25-1.36 (m, H'-11). 1 18 (H-29). 1.11 (H-30), 0.97 (H-19), 0.84 (H-18) ; 2.10 (OH), 2.01 (OAc), 1.99 (OAc)
1β, 2β-Diepoxyazadiradione (14)[2] Ai-s, $C_{28}H_{34}O_7$, 110-111°, —3.5°	3140, 1755, 1745, 1700, 1245, 1030, 1260, 875, 830	(360), 7.56 (m, H-21), 7.40 (m, H-23), 6.23 (m, H-22), 4.66 (m, H-7), 3.88 (H-17) 3.62 (d 4.5, H-1), 3.42 (d, 4.5, H-2), 3.40 (H-19), 2.92 (m, H-9), 2.45 (m, H-5), 2.20-1.80 (m, H-6, H-11, H-12), 2.07 (OAc), 1.19 (H-30), 1.09 (H-18), 1.06 (H-19), 1.03 (H-28), 0.97 (H-29)

TABLE 5 (Continued)

1	2	3
4α, 6α-Dihydroxy A-homoazadirone(15)[42], Ma-s, $C_{28}H_{36}O_6$, 177-178°, +75°	3430, 1735, 1675, 1375, 1240, 1020	(250), 7.39 (m, H-21), 7.25 (m H-23), 6.66 (d, 12, H-1), 6.28 (m, H-22), 5.93 (dd, 12 5, 2.3, H-2), 5.46 (dd, 1.7, 3.2, H-15), 5.31 (d, 2.6, H-7), 4.5 (ddd, 11.6, 2.6, 2.4, H-6), 4.42 (d, 1.7, OH-4), 3.53 (d, 2.4, H-6), 3.16 (dd, 12.4, 1.7, H-28), 2.85 (dd, 9.5 9.6, H-17), 2.65 (dd 12.4, 2 3, H'-28), 2.41 (ddd, 15.5, 1.7, 9.5, H-16), 2.36 (ddd, 15.5, 3.24, 9, H'-16), 2.33 (d, 11.6, H-5), 2.21 (m, H-9), 2.03 (OAc), 1.7-2.0 (m, H-9), 1.56 (H-29), 1.31 (H-30), 1.27 (H-19), 0.79 (H-18)
17-Epi-azdiradione(16)[58], Ai-s, $C_{28}H_{34}O_5$, 205°, -97°	3150, 1730, 1695, 1660, 1250, 1030, 870	(360), 7.33 (H-21), 7.17 (H-23), 7.12 (d,10, H-1), 6.04 (m, H-22), 5.87 (H-15), 5.86 (d, 10, H-2), 5.32 (m, H-7), 3.33 (H-17), 2 45 (m, H-9), 2.20 (m, H-5), 2.15-1.85 (m, H-6, H-11, H-12), 1.95 (OAc), 1.44 (H-18), 1.26 (H-30), 1.18 (H-19), 1.07 &1.06 (H-28, H-29)
Epoxyazadiradione(17)[47,49], Ai-s, $C_{28}H_{34}O_6$, 202-203°, +4°	225 (ε, 10, 800) ; 1751, 1736, 1678, 886	7.52, 7.35, 6.18 (furan) ; 7.1 (d, 10, H-1), 5.76 (d, H-2), 4.68 (H-7), 3.83 (H-17), 3.33 (t, H-15), 1.98 (OAc) ; 1.2, 1.19, 1.02, 1.0 (five methyls)
Gedunin(18)[49], Ai-s, $C_{28}H_{34}O_7$, 218°, −44°	225 (ε, 9000) ; 3106, 1740, 1725, 1680, 1660, 1500, 876	7.3 (m), 6.33 (m) (furan) ; 7.1 (d, 10, H-1), 5.83 (d, 10, H-2), 5.60 (H-17), 4.52 (m, H-15), 2.05 (OAc) ; 1.25, 1.22, 1.15, 1.05 (methyls)
17-β-Hyhroxy- azadiradione(19)[6] Ai-s, $C_{28}H_{34}O_6$, 177°, +106°	3430, 1740, 1715, 1695, 1670	(360), 7.58 (m, H-21), 7.42 (m, H-23), 7.16 (d, 10.7, H-1), 6.39 (m, H-22), 5.89 (d, 10.7, H-2), 5.78 (H-15), 5.33 (m, H-7), 2.59 (OH), 2.24 (m, H-9), 2.20 (m, H-5), 2.13-1.55 (m, H-6, H-11, H-12), 1.94 (OAc), 1.35 (H-30), 1.23 (H-19), 1.09 & 1.07 (H-28 & H-29), 0.96 (H-18)

TABLE 5 (Continued)

1	2	3
Isomeldenin(20)[64], Ai-l, $C_{28}H_{38}O_5$, 148-150°, +100°	290 (ε, 46) ; 1724, 1710, 1490, 1250, 880, 790	(60), 7.33, 7.28, 6.3 (furan) ; 5.33 (H-15), 5.31 (d, 2, H-7), 4.18 (q, 2, 12, H-6), 2.06 (OAc) ; 1.3, 1.28, 1.2, 0.85, 0.80 (five methyls)
Kulinone(21),[65, 66] Ai-b, $C_{30}H_{48}O_2$, 138°, −20°	3520, 1715, 1640, 1020, 990, 847, 826	5.3 (m), 5.1 (m), 4.05 (m, OH), 1.57-1.69 (— CH =CMe$_2$), 0.82-1.36 (methyls)
Meldenin(22)[67], Ai-l, o, $C_{28}H_{38}O_6$, 243-245°, +187°	290 (ε, 46) ; 3500, 1728, 1700, 1498, 1246, 880, 798	(60), 7.33, 7.28, 6.3 (furan) ; 5.56 (H-15), 5.3 (q, 2, 12, H-6), 4.06 (d, 2, H-7), 2.15 (OAc) ; 1.28, 1.21, 1.1, 0.88, 0.83, (five methyls)
Meldenindiol(23)[64], Ai-l, $C_{26}H_{34}O_4$, 205°, +60°	227 (ε, 8277), 330 (ε, 118) ; 3500, 1670, 1500. 880	(60), 7.33, 7.28, 6.3 (furan) ; 7.08 (q, 10, H-1), 5.85 (q, 10, H-2), 5.56 (H-15), 4.25 (q, 2, 12, H-6), 4.0 (d, 2, H-7) ; 1.36, 1.35, 1.2, 1.1, 0.83 (five methyls)
Melianin-A(24)[68], Ma-w, $C_{41}H_{68}O_9$, 258-259°	3500, 1730, 1226, 715	8.05 (m), 7.45 (m) (aromatic), 5.36 (m, H-15), 5.20 (m, H-7), 4.89 (m, H-3), 4.70 (m, H-1), 3.38-3.99 (H-21), 2.85 (d, 9, H-24), 2.28, 2.06 (OAc), 1.66 (OAc) ; 1.26, 1.24, 1.16, 0.98 & 0.9 (methyls)
Melianin-B(25)[68], Ma-w, $C_{41}H_{68}O_9$, 198-201°	3400, 1720, 714	5.33 (m, H-15), 5.18 (m, H-7), 4.90 (m, H-3), 4.70 (m, H-1), 2.04 (OAc), 1.64 (OAc) ; 1.27, 1.14, 1.0, 0.9 (methyls)
Melianol(26)[69], Ai-f, $C_{30}H_{48}O_4$, 194-195°, −38°	210 (ε, 2700) ; 3600, 3440, 1630, 1030, 980, 830	5.35, 3.8, 3.3, 2.93, 1.33, 1.02, 1.0, 0.86 0.76

TABLE 5 (Continued)

1	2	3
Melianone(27)[60], Ai-f, $C_{30}H_{46}O_4$, 223-224°, −26°	210 (ε, 2600) ; 3340, 1709, 1635, 1242, 820	5.38, 3.0, 2.9, 1.3, 1.12, 1 04, 0.86
Meliantriol(28)[61], Ai, Ma-f, $C_{30}H_{50}O_5$, 176-178°, −23°		5.35, 3.6, 3.0, 1.4-0.7
Meliatoxin-A_1(29)[1] Ma-f, $C_{35}H_{46}O_{12}$, 148-154°	210 (ε, 6560) ; 3610, 3460, 3030, 1745, 1710, 1430, 1375, 1250, 1050, 910, 870	7.38 (H-23), 7.14 (H-21), 6.14 (H-22), 5.91 (t, 4.4, H-2), 5.78 (H-29), 5.52 (d, 4.4, H-3), 4.61 (H-9), 4.50 & 4.40 (q, 13, H-19), 4.24 (d, 4.4, H-1), 3.71 (H-15), 3.69 (t, 3, H-7), 2.76 (dd, 11, 6, H-17), 2.75 (dd, 14.4, H-5), 2.46 (H-12), 2.26 (dd, 14, 6, H-16), 2.14 (COOMe), 2.02 (COOMe), 2.0 (m, H-6), 1.88 (dd, 14, 11, H'-16), 1.78 (m, H'-6), 1.24 (H-18), 1.09 (H-30), 0 85 (H-28) ; 0.94 (t, 7), 1.18 (d, 7), 1.55, 1.72, 2.51 ($OCOCHMeCH_2Me$ at C-29)
Meliatoxin-A_2(30)[16], Ma-f, $C_{34}H_{44}O_{12}$, 155-160°	identical to (29)	identical to (29) except for $OCOCHMe_2$ at C-29, 2.69 (m), 1.22 (d, 7), 1.21 (d, 7)
Meliatoxin-B_1(31)[1] Ma-f, $C_{35}H_{44}O_{11}$, 140-150°	207 (ε, 8500) ; 3600, 3480, 3040, 1745, 1710, 1462, 1375, 1250, 1050, 905, 875	7.41 (H-23), 7.29 (H-21), 6.31 (H-22), 5.9 (t, 4.4, H-2), 5.78 (H-29), 5.57 (d, 4.4, H-3), 4.27 & 4.66 (q, 13, H-19), 4.27 (d, 4.4, H-1), 3.97 (t, 3, H-7), 3.48 (H-9), 3.34 (t, 10, H-17), 3.16 (H-14), 2.66 (m, H-5), 2.59 (d, 10, H-16), 2.31 & 2.68 (q, 17, H-12), 2.14 (m, H-6), 2.14 (OAc), 2.04 (OAc), 1.83 (dt, 15, 3.5, H'-6), 1.05 (H-18), 0.99 (H-30), 0.86 (H-28) ; 2.50 (m), 1.53 & 1.72 (m), 1.19 (d, 7), 0.94 (t, 8), ($OCOCHMeCH_2Me$ at C-29)

TABLE 5 (Continued)

1	2	3
Meliatoxin-B_2(32)[48], Ma-f, $C_{34}H_{42}O_{11}$, 155-162°	identical to (31)	identical to (31) except for $OCOCHMe_2$ at C-29, 1.22 (d, 7), 1.21 (d, 7)
1 -Methoxy, 1, 2-dihydroepoxyazadiradione(33)[22], Ai-s, $C_{29}H_{38}O_7$, 235-236°, −1.4°	3150, 1763, 1735, 1700, 1245, 1095, 1030, 875, 835	(360), 7.53 (m, H-21), 7.20 (m, H-23), 6.24 (m, H-22), 4.66 (m, H-7), 3.88 (H-17), 3.39 (t, 3.7, H-1), 3.37 (H-15), 3.32 (OMe), 3.24 (m, H-9), 2.90 (dd, 3.7, 16.5, H-2), 2.64 (dd, 3.7, 16.5, H'-2), 2.24 (m, H-5), 2.04 (OAc), 2 13-1.50 (m, H-6, H-11, H-12), 1.17 (H-30), 1.11 (H-19), 1.05 (H-18), 1.02 & 0.99 (H-28 & H-29)
Nimbaflavone(34)[6] Ai-l, $C_{26}H_{30}O_5$, 126-128°, −196° (MeOH)	290, 355 (sh) ; 3400, 1640, 1620, 1510	(90), 7.1-7.25 (m, H-2, H-6), 6 85 (d, 10 H-5), 5.85 (Ar-H), 5.3 (dd, 10, 4), 5.1 (t, 2.5) & 5.2 (t, 2.5), 3.7 (OMe), 3.2 (m, Ar-CH_2), 2.85 (m, 1, H-3), 1.67-1.72 (m, 2 X $-CH{=}C(CH_3)_2$)
Nimbandiol(35)[49], Ai-s, o l, $C_{26}H_{32}O_7$, 121°, +187.9°	3420, 3320, 3100, 1685, 1500, 1740, 1266. 1035, 1125, 880	(360), 7.33 (m, H-21), 7.21 (m, H-23), 6.53 (d, 10, 2, H-3), 6.26 (m, H-22), 5.75 (d, 10, 2, H-2), 5.48 (dddq, 7, 7.1, 1.8, H-15), 4.29 (OH), 4.24 (ddd, 7.5, 3.5, 11 5, H-6), 3.99 (d, 3.5, H-7), 3.65 (d, 8, H-17), 3.63 ($COOCH_3$), 3.14 (d, OH), 2.91 (dd, 16.5, 6, H-11), 2.70 (dd, 4, H-9), 2.66 (d, 11.5, H-5), 2.18 (dd, 16.5, 4, H-11), 2.16 (dd, 12, 7, H-16), 2.02 (ddd, 8, 12, H'-16), 1.67 (d, 1.8, H-18), 1.58 (H-19)
Nimbidic acid(36)[49], Ai-s, $C_{26}H_{34}O_7$, 228-230°	3400, 2900, 1715, 1460, 1350, 1200, 1180, 1060, 1040, 960, 880, 790	Methyl ester, 7.35, 6.2, 5.5, 4.55, 4.25, 3.8-4.1, 3.60, 2.70, 2.45, 2.13, 1.72, 1.28, 1.10, 0.90

TABLE 5 (Continued)

1	2	3
Nimbidinin(37)[63,64], Ai-s, $C_{26}H_{34}O_6$, 282-284°	225 ; 3400, 2900, 1708, 1460, 1340, 1160, 1070, 1020, 820 .	Nimbidinin triacetate : 7.45, 6.65 (furan) ; 5.6 (H-7), 4.97 (H-1), 4.70 (H-3), 4.20 (H-6), 3.55 (H-28), 2.7 (H-5) ; 2.2, 2.0, 1.99 (3 x OAc) ; 1.17, 1.02, 1.0 (4 x Me)
Nimbin(38)[65-77], Ai-s, b, $C_{30}H_{36}O_9$, 205°, +170°	1739, 1688	7.34, 7.25, 6.35, 3.73, 3.64, 2.03, 6.37, 5.8
Nimbinene(39)[49], Ma-l, b, s, $C_{28}H_{34}O_7$, 134°, + 168°	3100, 1750, 1735, 1715, 1500, 1260, 1240, 1040, 1030, 870	(500), 7.32 (m, H-21), 7.22 (m, H-23), 6.28 (m, H-22), 5.60 (dddq, 1, 5 5, 3, 1, H-3), 5.36 (dd, 12.5, 3.5, H-6), 5.50 (dddq, 6.8, 8, 1, 2, H-15), 4.08 (d, 3.5, H-7), 3.64 (d, 1, H-17), 3.30 (d, 12.5, H-5), 3.01 (dddq, 3.2, 1, H-2), 2.90 (dddq, 19.5, 5.5, 1.5, 1, H'-2), 2.82 (dd, 16.5, 6, H-11), 2.74 (t, 6, H-9), 2.26 (dd, 16.5, 6, H-11), 2.17 (dd, 12, 6.8, H-16), 2.14 (OAc), 2.04 (ddd, 8.5, 12, 8, H-16), 1.78 (m, H-29), 1.68 (dd, 2, 1, H-18), 1.38 (H-30), 1.12 (H-19)
Nimbinin(40)[78], Ai-s, $C_{28}H_{34}O_6$, 202-204°, +45°	219 (ε, 18,000) ; 1750, 1730, 1670, 1500, 878	7.58 (H-21), 7 33 (H-23), 7.1, 6.22 (H-22), 5.8, 4.66, 3.82, 3.3 (H-22), 5.8, 4.66, 3.82, 3.3 (H-15), 2.01 (OAc) ; 1.17, 1.15, 1.00, 0.98 (five methyls)
Nimbolide(41)[79,80], Ai-l, $C_{27}H_{30}O_7$, 245°, −47°,	1665, 1770, 1720	Not reported

TABLE 5 (Continued)

1	2	3
Nimbolidin-A(42)[15], Ma-f, $C_{40}H_{48}O_{12}$, 178°, −32°	1740, 1730, 1270, 1250, 1235, 1060, 880	7.05 (m, H-23), 6.12 (m, H-22), 5.82 (d, 6.8, H-15), 5.76 (d, 2.8, H-7), 4.96 (t, 3, H-3), 4.52 (t, 3, H-1), 4 22 (dd, 12.7, 2.8, H-6), 3.83 (dd, 5.6, 8, H-9), 3.46 (d, 7.5, H-28), 3.41 (d, 8 5, H-17), 3.37 (d, 7.5, H-28), 3.03 (d, 12.7, H-5), 2.42 (ddd, 15, 6.8, 8.5, H-16), 2.33 (m, H-11), 2.29 (dt, 13, 3, H-2), 2.22 (dt, 13.3, H'-2), 2.2 (OAc), 1.6 (d, 15, H-16), 2.16 (OAc), 2.03 (OAc), 1.78 (H-18), 1.3 (H-30), 1.23 (H-29), 1.2 (H-19) ; 8.04 (d), 7.49 (t), 7 33 (t) (benzoyl), 3.59 (COOCH$_3$)
Nimbolidin-B(43)[1] Ma-f, $C_{38}H_{50}O_{12}$, 180°, − 9.2°	1740, 1720, 1270, 1250, 1060, 880	7.25 (m, H-21), 7.20 (m, H-23), 6.2 (m, H-22), 5.75 (d, 6.8, H-15), 5.58 (d, 3, H-7), 4.94 (t, 3, H-3), 4.48 (t, 3, H-1), 4.14 (dd, 12.6, 3, H-6), 3.7 (dd, 6, 9, H-9), 3.58 (CO_2CH_3), 3.49 (d, 7.5, H-28), 3.43 (d, 8.6, H-17), 3.42 (d, 7.5, H-28), 2.84 (d, 12.6, H-5), 2.38 (ddd, 15.5, 6 8, 8.6, H-16), 2.23 (dt, 13, 3, H-2), 2 19 (dt, 13, 3, H'-2), 2.3 (dd, 14, 9, H-11), 2.25 (dd, 14, 6, H'-11), 2.15 (OAc), 2.08 (OAc), 2.0 (OAc), 1.8 (H-18), 1.56 (d, 15.8, H'-16), 1.25 (H-30), 1.21 (H-29), 1 16 (H-19) ; 6.81 (qq, 7.1), 1.7 (dq, 7), 1.99 (tigloyl)
Nimbolin-A(44)[81], Ai, Ma, w, $C_{39}H_{46}O_9$, 180-183°, −38.6°	873	7.17, 6.17 (furan) ; 3.46 (t, 4.5, H-15), 2.13, 1.83, 1.23, 1.20, 1.05, 0.86 ; 7.62, 7.33, 6 3 (cinnamoyl)

TABLE 5 (Continued)

1	2	3
Nimbolin-B(45), Ai, Ma w, $C_{39}H_{46}O_{11}$, 243-245°, −93.3°	Not reported	Not reported
Nimbollnin-B(45)[15], Ma-f, $C_{35}H_{46}O_{10}$, Amorphous, −59 5°	3450, 1740, 1720, 1260, 1240	7.3 (m, H-21), 7.23 (m, H-23), 6.35 (m, H-22), 5.79 (d, 3, H-7), 5.23-5.28 (m, H-12), 5.19 (d, 8, H-15), 4.94 (t, 3, H-3), 4.79 (t 3, H-1), 4.12 (dd, 13, 3, H-6), 3.54 (d, 7, H-28), 3.46 (d, 7, H'-28), 3.27 (d, 8, H-17), 3.23 (d, 10, H-9), 2.85 (d, 13, H-5), 2.09 (OAc), 2.01 (OAc) 2.39-2.52 (m, OH-12), 2 28 (ddd, 14, 8, 9, H-16), 2.28 (m, H'-11), 2.20-2.26 (m, H-2), 1.78 (H-18), 1.63 (m, H-11), 1.49 (d, 14, H-16), 1.45 (H-30), 1.18 (H-29), 1.00 (H-19) ; 6.97 (qq, 7, 1), 1.93 (d, 1), 1.82 (m) (tigloyl)
Ohchinal(47)[82], Ma-f, $C_{35}H_{40}O_8$, 265-270°, +107°	282 (ϵ, 1820), 275 (ϵ, 1880), 225 (ϵ, 14800) ; 3150, 3080, 2740, 1740, 1725, 1700, 1605, 1510, 870	8.88 (br.ddd, 4, 4, 1.5, H-12), 7.16, 6.99, 5 78 (furan); 5.33 (m, H-15), 5,05 (t, 3, H-1), 5, 02 (t, 3, H-3), 4.23 (d, 3, H-7), 4.04 (dd, 12, 3, H-6), 3,81 & 3.64 (q, 8, H-30), 2.97 (d, 12, H-5), 2.35 (t, 3, H-2), 1.79 (OAc), 1.55 (d, 2, H-18), 1.29 & 1.05 (methyls)
Ohchinin(48)[43], Ma-f, $C_{36}H_{42}O_8$, 184-185°, +64°	276 (ϵ. 19,000), 215 (ϵ, 22,000); 3450, 3140, 1725, 1695, 1625, 1570 ; 1300, 1264, 1160, 865, 795, 770	7.14 (dd, 1.4, 1.0, H-21), 7.13 (dd, 1.9, 7.4, H-23,), 6.18 (dd, 1.9, 1, H-22), 5.48 (dddq, 15, 8.4, 6.8, 1.9, 1.4, H-15), 5.09 (dd, 2.7, 2.7 H-1), 4,21 (d, 3.2, H-7), 4.04 (dd, 12.4, 3.2, H-6), 3.91 (ddd, 8.9, 3, 3, H-3), 4.17 (d, 7.6, H-28), 3.66 (d, 7.6, H-28), 2.78 (d, 12.4, H-5), 2.71 (dd, 9.5, 3.0, H-9), 2.31 (ddd, 12.8, 3, 2.7 H-2), 2.24 (ddd, 12.2, 8.6, 6.8, H-16), 2.14 (ddd, 13.8, 3, 2.7, H-2), 2.18 (dd, 15.1, 3, H-11), 2.34 (dd, 15.1, 9.8, H-11), 2.15 (dd, 12.2, 8.4, H-16), 1.65 (d, 1.4, H-18), 1.32 (H-30), 1.17 (H-29), 0.98 (H-19), 3.11 (COOMe), 2.46 (d, 8,9, OH); 6.5 (d, 15.9), 7.72 (d, 15), 7.57 (m), 7.41 (m) & 7.41 (m) (cinnamoyl)

TABLE 5 (Continued)

1	2	3
Ohchininacetate (49)[52], Ma-f, $C_{38}H_{44}O_9$, 223-226°, +227° (EtOH)		7.18, 7.16, 6.23 (furan); 5.57(m, H-15), 5.01 (t, 3, H-3), 4.87 (t, 3, H-1), 4.25 (d, 3, H-7), 4.05 (dd, 12, 3, H-6), 3.79 & 3.63 (q, 8, H-30), 3.21 (COOMe), 2.93 (d, 12, H-5), 2.31 (H-2), 1.95 (OAc), 1.70 (d, 2, H-18); 1.34, 1.26, 1.03 (methyls) ; 7.80 (d, 16) & 6.47 (d, 16) (cinnamoyl)
Ohchinolal(50)[53], Ma-f, $C_{34}H_{44}O_{10}$, 163-164°, —5° (EtOH)	215 (ε, 1500); 3475, 3150, 1730, 1710, 1690, 1645, 1500, 1250, 1040, 970, 875	9.74 (H-28), 7.33 (dd, 1.9, 1.6, H-23), 7 25 (dd, 1.9, 0.8, H-21), 6 29 (dd, 1.6, 0.8, H-22), 5 49 (dddq, 7.8, 6.8, 1.8, 1 4, H-15), 5 26 (dd, 12 2, 2.7, H-6), 5 08 (dd, 3.2, 2.7, H-1), 4.03 (d, 2.7, H-7), 3 75 (ddd, 9.2, 3 5, 2.7, H-3), 3.66 (d, 12.2, H-5), 3.63 (dd, 9.2, 1.8, H-17), 2.84 (dd, 8.4, 3.2, H-9), 2.24 (dd, 15.7, 3.2, H-11), 2.32 (dd, 15.7, 8.7, H-11), 3.23 (COOMe), 2.22 (ddd, 16.2, 3.5, 2.7, H-2), 2.02 (ddd, 16.2, 3.2, 2.7, H-2), 2.27 (dd 12.4, 6.8, H-16), 2.09 (ddd, 12 4, 9.2, 7.8, H-16), 2.73 (d, 9.2, OH), 1.98 (OH), 1.65 (d, 1.4, H-18), 1.41 (H-30), 1.08 (H-19), 1.00 (H-29); 6.94 (q, 7, 1.6), 1.86 (dq, 7.0, 1.1) (tigloyl)
Ohchinolide-A(51)[15],[51], Ma-f, $C_{35}H_{44}O_{10}$, 230-231°, —42.5°	3080, 1735, 1270, 1235, 1060, 880	(300), 7.30 (m, H-21), 7.24 (m, H-23), 6.29 (m, H-22), 5.9 (d, 2.7, H-7) 5.55 (d, 6.8, H-15), 4.98 (t 3, H-3), 4.84 (t, 3, H-1), 4.18 (dd, 12.7, 2.7, H-6), 3.52 (d, 7.7, H-28), 3.41 (d, 7.7, H'-28), 3.4 (dd, 12.7, 3.5, H-9), 3.34 (d, 9, H 17), 2 97 (d, 12.7, H-5), 2.80 (dd, 18, 12.7, H-11), 2.66 (dd, 18, 3.5, H-11), 2.29 (t, 3, H-2), 2.24 (OAc), 1.98 (OAc), 1.89 (H-18), 1.78-1.86 (m, H-16), 1.53 (H-30), 1.22 (H-29), 1.10 (H-19); 7.46 (t), 7.62 (t), 8.12 (d) (benzoyl)

TABLE 5 (Continued)

1	2	3
Ohchinolide-B(52)[15,21], Ma-f, $C_{35}H_{44}O_{16}$, 211-212°, −46.5°		(300), 7.32 (m, H-21), 7.27 (m, H-23), 6.32 (m, H-22), 5.72 (d, 2.7, H-7), 5.57 (d, 7, H-15), 4.96 (t, 3, H-3), 4.79 (t, 3, H-1), 4.10 (dd, 12.7, 2.7, H-6), 3.54 (d, 7.6, H-28), 3.41 (d, 9, H-17), 3.24 (dd, 3, 12.8, H-9), 2.81 (d, 12.7, H-5), 2.61 (dd, 18.3, H-11), 2.26 (t, 3, H-2), 2.20-2.32 (m, H-16), 2.12 (OAc), 2.02 (OAc), 1 94 (d, 15, H-16), 1.84 (H-18), 1.48 (H-30), 1.20 (H-29), 1.06 (H-19), 6.95 (qq, 7.2, 1), 1.92 (d, 1), 1 84 (dq, 7.2, 1) (tigloyl)
Salannin(53)[44,55], Ai-s, $C_{34}H_{44}O_9$, 167-170°, +167°	1743, 1653, 1710	7.35, 7.0, 6.33, 3.28, 2.0-1.75, 1.95, 1.69, 1.33, 1.23, 1.0
Salannol(54)[50], Ai-o, $C_{32}H_{44}O_8$, 208°, +108.7°	3440, 3140, 1740, 1730, 1510, 1200, 1170, 1090, 1050, 880	7.33 (m, H-21), 7 26 (m, H-23), 6.23 (m, H-22), 5.43 (dddq, 1.5, 1, 7, 7, H-15), 5.03 (t, 3, H-1), 4.16 (d, 3, H-7), 4.1 (d, 7.5, H-28), 3.98 (dd, 12, 3, H-6), 3.61 (d, 7.5, H'-28), 3.60 (dbr, 8, 1, 1, H-17), 3.40 (dt, 3, 3, H-3), 2.59 (d, 12, H-3), 2.58 (dd, 2.5, 10, H-9), 2.32 (dd, 16, 10, H-11), 2.23 (dd, 12.5, 7, 1, H-16), 2.12 (ddd, 7, 8, 12 5, H'-16), 2.10 (dd, 16, 2.5, H'-11), 2.26 (dt, 3, 16, H-2), 1.97 (dt, 16, 3, H'-2), 1.61 (d, 1.6, H-18), 1.29 (H-30), 1.12 (H-29), 0.92 (H-19) ; 2.42 (dd, 16, 7), 2.31 (dd, 16, 7), 2.10 (m), 1.0 (d, 7), 1.0 (d), 3.24 ($COOCH_3$), 2.54 (d, 10, OH)
Sendanal(55)[46], Ma-f, $C_{30}H_{40}O_9$ 276-277°, −14° (EtOH)	3600, 3520, 3440, 3135, 2740, 1760, 1730, 1720, 1510, 875	9.50 (H-28), 7.35, 7.25, 6.28 (furan) ; 5.67 (t, 2.5, H-15), 5.07 (t, 2.5, H-12), 5.03 (t, 3.5, H-3), 4.13 (dt, 12, H-6), 4.02 (m, H-7), 3.45 (dt, 10, H-1), 3.05 (d, H-5), 2.06 & 1.91 (OAc) ; 1.29, 1.20, 1.14, 0.96 (methyls)

TABLE 5 (Continued)

1	2	3
Sendanin(56)[67], Ma-f, $C_{32}H_{40}O_{12}$, 251-252°, + 4.3°	210 (ϵ, 8790): 3590, 3460, 3150, 1735, 1720, 1510, 1270, 885	7.39 (d, 2, H-23), 7.24 (H-21), 6.19 (d, 2, H-22), 6.10 (H-28), 5.82 (H-12), 5.32 (H-9), 5.47 (br, 5, H-3), 4.58 (H-19), 4.74 (m, H-1), 3.84 (m, H-7), 3.91 (H-15); 1.92 & 1.82 (OAc), 1.82, 1.24 & 0.93 (Me); 6.20 (d, 4, OH), 6.61 (d, 4, OH)
Sandanol-actone(57)[68], Ai-b, $C_{30}H_{42}O_4$, 208.5-209°, --30°	246 (ϵ, 16, 400); 1780, 1715, 1655, 1625	5.11, 1.72, 1.64, 1.38, 1.34, 1.13, 1.00
Triterpene-B(58)[23], Ma-f, r, $C_{30}H_{48}O_3$, 173-175°, --26.5°	247 (ϵ, 1530), 239 (ϵ, 1760); 3430, 2975, 2940, 2890, 1610, 1466, 1390, 1385, 1245, 1035, 900, 825, 805	(60), 5.3 (m), 3.45, 2.78 (q, 2.5, 7.5), 2.52 (d), 1.40, 1.34, 1.00, 0.97, 0.85, 0.80, 0.75
Vepinin(59)[69], Ai-o, $C_{29}H_{36}O_5$, amorphous, + 14°	1745, 1670, 1250, 1035	7.3, 7.3, 6.21 (furan); 7.05 & 5.73 (d, 10 H-1 & H-2), 5.28 (d, 3.12, H-6), 4.18 (d, 3, H-7), 4.05 (m, H-15), 1.90 (OAc); 1.22, 1.19, 1.04, 0.80 (methyls)

*Unless stated otherwise

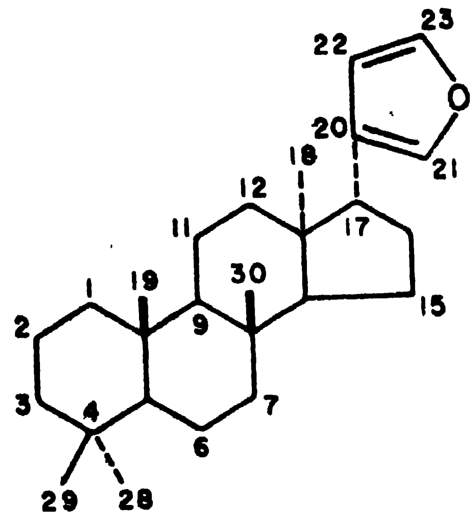
Abbreviations used for sources: Ai, Azadirachta indica; Ma, Melia azedarach; s, seeds; l, leaves; o, oil; b, bark; f, fruit; r, root; w, wood.

In a few complex cases, even the newer techniques of various spectroscopy are found inadequate to arrive with certainty at the correct structure. In such cases, X-ray crystallography is an useful tool if, however, the substance is crystalline in nature The final confirmation of the structure and stereochemistry of Ohchinolide A(51) was made by X-ray deffraction[21] method. The structure and stereochemistry of 7-acetylneotrichlenone(1) have been established by X-ray crystallography[22].

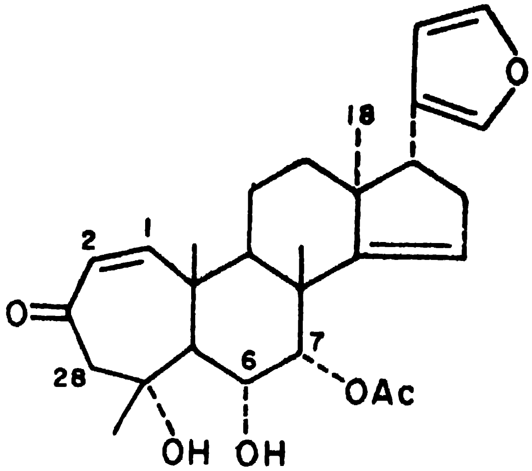
(c) *Structural features :* The limonoids, which are dominating constituents of *A. indica* and ***M. azedarach***, are a class of C_{26} degraded triterpenes whose structural features arise by the modification of euphol/tirucallol type of tetracyclic triterpenes. The two main catabolic processes involved are (i) the loss of terminal four carbon atoms of the side chain and formation of β-substituted furan ring from the remainder and (ii) the frequent expansion of a carbocyclic ring into a lactone or ring-opened derivative. There have been extensive studies on the species during recent years, leading to the isolation of a number of tetranortriterpenoids and a few other types of constituents. A compilation of all the tetranortriterpenoids and a few other constituents isolated from the two plants along with their physical and spectroscopic (UV, IR and ^{1}H NMR) data is presented in Table 5. Some well-known products other than limonoids *viz.* 24-methylene cycloartenone, cycloeucalenone, 4-stigmasten-3-one, 4-campesten-3-one, 24-methylene cycloartanol, triacontanol, cycloeucalenol, sitosterol, sistosterol-β-D-glucoside vanillic aldehyde, trans cinnamic acid, vanillic acid[23], quercetin rutin[24], 7-triacosanol[25], melicitrin[26], tiglic acid[27], myricetin[28], quercetin-3-galactoside, kaemferol-3-glucoside, myrecetin-3-L-arabinoside[29], 4, 14 α-dimethyl-5 α-ergosta-8, 24 (28)-dien-3-β-ol, 4-methyl-5 α-ergosta-8, 24 (28)-dien-3β-ol[30] and a few polysaccharides [31, 32] which have also been isolated from the two plant species are excluded from Table 1.

(d) *Ring system* : All the limonoids isolated so far from the two plant species have carbocyclic A-rings which is characteristic of all the Meliaceae. However, many ot the compounds, *viz.* nimbin(38), nimbolide(41), salannin(53) etc. possess a seco C-ring. The limonoids, with the intact carbocyclic system of the tetracyclic triterpene precursor, are in majority and no compound having a seco B-ring has yet been isolated from any of these two plants.

(e) *Oxygen functions :* The oxygenation pattern found in the limonoids of the two plants deserves comment. The 14,15-epoxy frequently occurs and so also the 7, 15 and 6, 28-oxide rings. A 19, 29-hemiacetal such as in sendanin(56) has been detected in a number of compounds. A group of compounds in which the D-ring is expanded into a δ-lactone have been isolated while sendanolactone(57) in which the D-ring is present as a γ-lactone has also been isolated. A γ-lactone involving C-28 and C-6 has been reported to occur, e.g., in nimbolide(41). Interestingly, ohchinolide A(51) and ohchinolide B(52) contain a seven-membered 12,15-lactone. The other oxygen functions *viz* hydroxy, ketonic, acetoxy etc. very often occur at 3- and 7-positions, while such functions may be present sometimes at 1-, 6-, 11- and 15-positions. The C-12 methyl ester is common to ring C-seco limonoids. The other ester functions, e. g. benzoyl at 7-positions in nimbolidin A(42), ohchinolide A(51) and 7-desacetyl, 7-benzoyl gedunin (9), cinnamoyl at 7-position in nimbolin B (45) and at 1-position in ohchinin(48), tigloyl at 1-position in salannin(53), at 7-positions in nimbolinin B(46), nimbolidin A(42) and nimbolidin B(43) as well as at



(1) 3, 15-Dioxo ; 7α-OAc ; Δ^1
(3) 3, 16-Dioxo ; 7α-OAc ; Δ^1
(4) 3-Oxo ; 7α-OAc ; $\Delta^{1,14}$;
(7) 3, 16-Dioxo ; 7α-OBz ; Δ^1
(8) 3, 16-Dioxo ; 7α-OBz ; 14β, 15β-epoxy ; Δ
(14) 3, 16-Dioxo ; 7α-OAc ; 1β, 2β, 14β, 15β-diepoxy ;
(16) 3, 16-Dioxo ; 7α-OAc ; 17α-H ; $\Delta^{1,14}$;
(17) 3, 16-Dioxo ; 7α-OAc ; 14β, 15β-epoxy ; Δ^1 ;
(19) 3, 16-Dioxo ; 7α-OAc ; 17β-OH ; $\Delta^{1,14}$;
(33) 3, 16-Dioxo ; 7α-OAc ; 14β, 15β-epoxy ; 1α-OMe ;
(20) 3-Oxo ; 6α-OH ; 7α-OAc , Δ^{14} ;
(22) 3-Oxo ; 6α-OAc ; 7α-OH ; Δ^{14} ;
(23) 3-Oxo ; 6α, 7α-$(OH)_2$; $\Delta^{1,14}$;
(40) 1, 16-Dioxo , 7α-OAc ; 14β, 15β-epoxy ; Δ^2 ;
(55) 1α, 6α, 7α-$(OH)_3$; 3α, 12α-$(OAc)_2$; 28-CHO ; Δ^{14} ;
(59) 3-Oxo ; 6α-OAc ; 7α, 15α-epoxy ; Δ^1 ;



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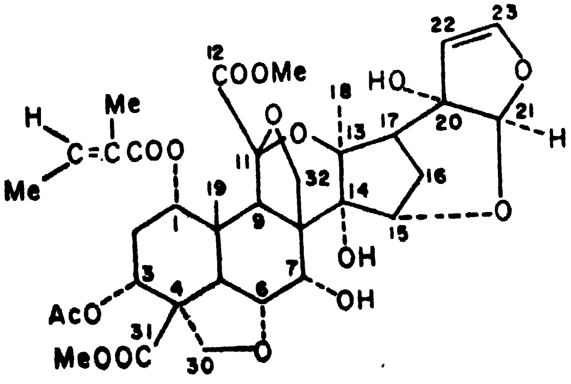

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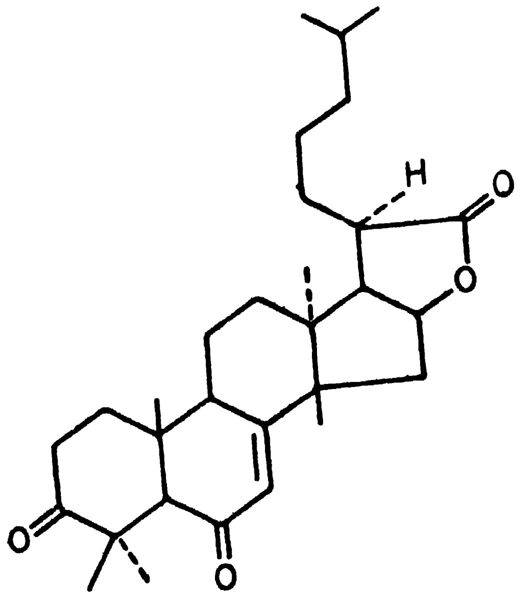

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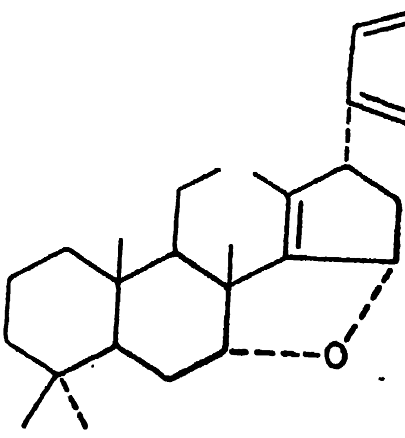
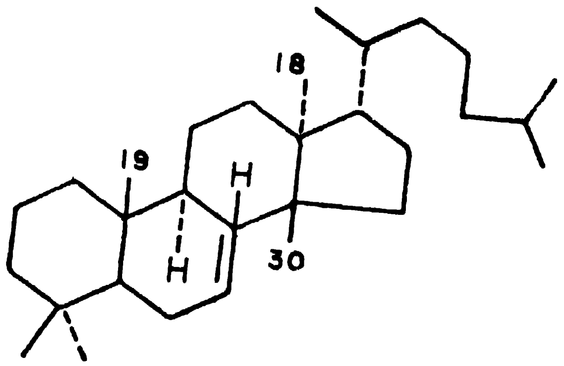
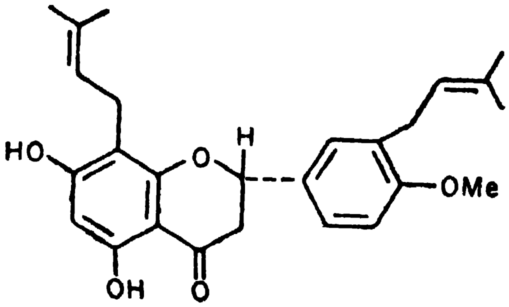


(10) 1-Oxo ; 6α-OH ; 12, 29-(COOMe)$_2$; Δ^2 ;
(38) 1-Oxo ; 6α-OAc ; 12, 29-(COOMe)$_2$, Δ^2 ;
(50) 1α-Tigloate ; 3α-OH ; 6α-OAc ; 12-COOMe
28-CHO



(21) 3-Oxo ; 16-OH ; Δ^{7,24} ;
(58) 21-OH ; 21, 23-, 24, 25-diepoxy ; Δ^7 ;
(26) 3β, 21α-(OH)$_2$; 21β, 23β-, 24β, 25β-diepoxy ;
(27) 3-Oxo ; 21α-OH ; 21β, 23β-, 24β, 25-diepoxy ;
(28) 3β. 21α, 24β, 25β-(OH)$_4$; 21β, 23β-epoxy



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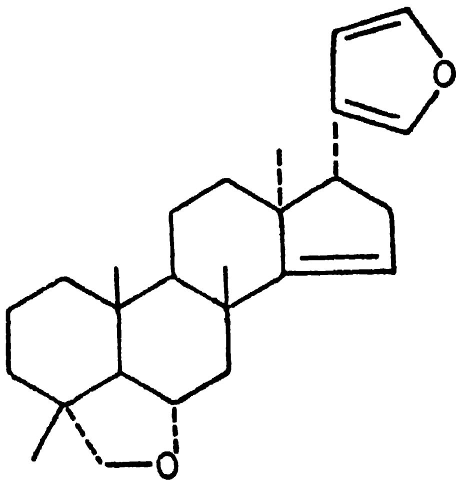
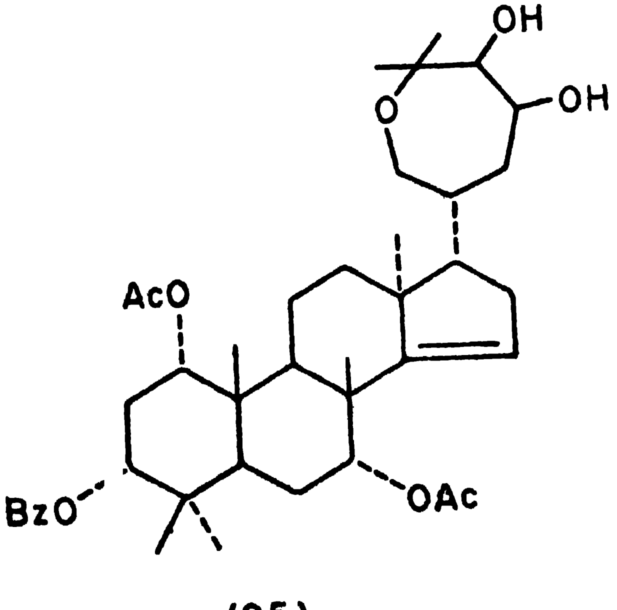


(13) 1α, 3α-(OAc)$_2$; 7α-OH ;
(44) 1α, 3α-(OAc)$_2$; 7α-cinnamoyl
(37) 1α, 3α, 7α-(OH)$_3$; 12-oxo



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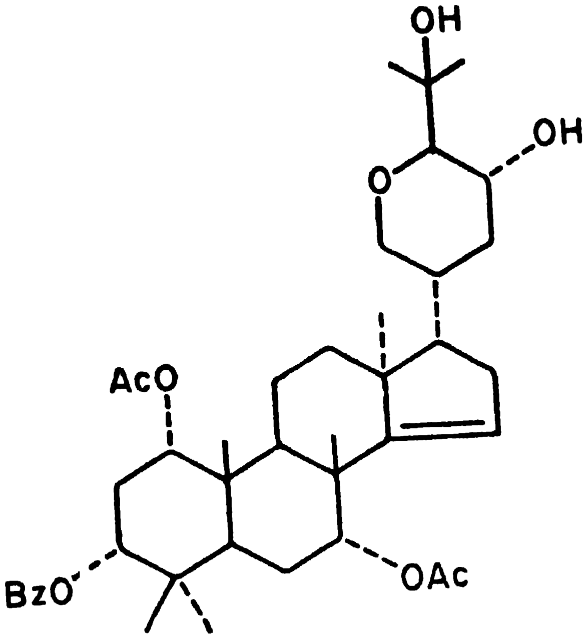

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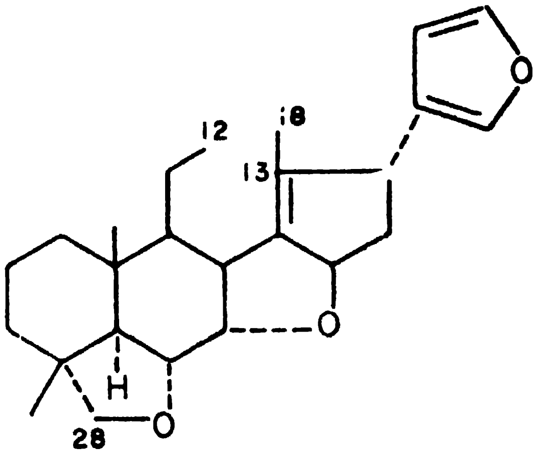
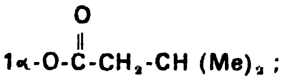
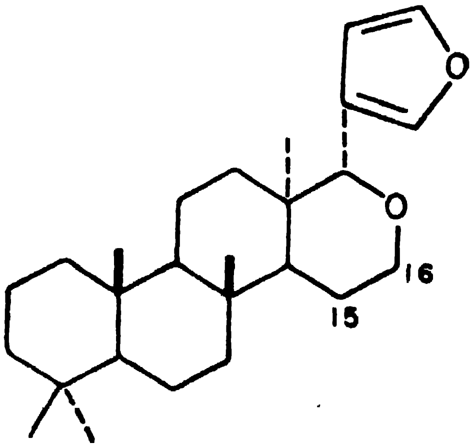
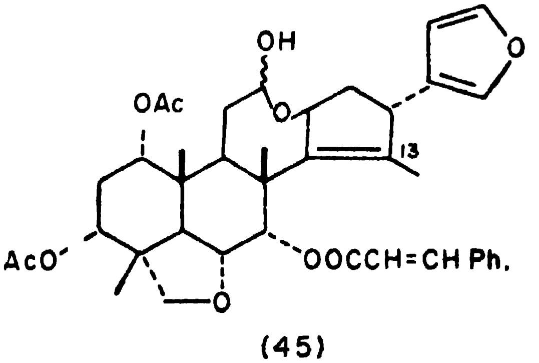


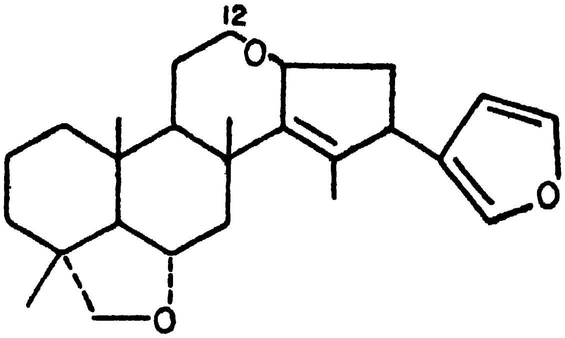
(6) 1α-Tigloate ; 3α-OH ; 12-COOMe ;
(36) 1α, 3α-$(OH)_2$; 12-COOH ;
(41) 1, 28-Dioxo ; 12-COOMe ; Δ^{3} ;
(47) 1α-OBz ; 3α-OAc ; 12-CHO ;
(48) 1α-Cinnamoyl ; 3α-OH ; 12-COOMe ;
(49) 1α-Cinnamoyl ; 3α-OAc ; 12-COOMe ;
(53) 1α-Tigloate ; 3α-OAc ; 12-COOMe ;
(54) 
$1\alpha\text{-O-}\overset{\overset{O}{\|}}{C}\text{-}CH_2\text{-}CH\,(Me)_2$; 3α-OH , 12-COOMe ;



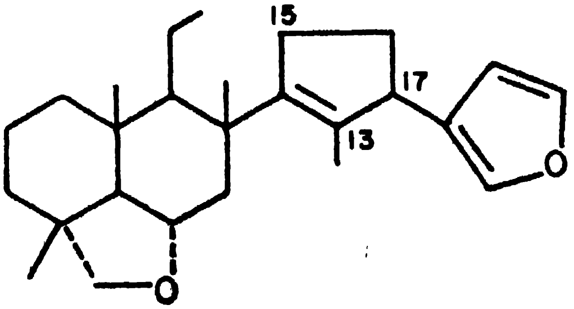
(9) 3,16-Dioxo ; 7α-OBz ; 14β, 15β-epoxy ; Δ^{1}
(18) 3,16-Dioxo ; 7α-OAc ; 14β, 15β-epoxy ; Δ^{1}



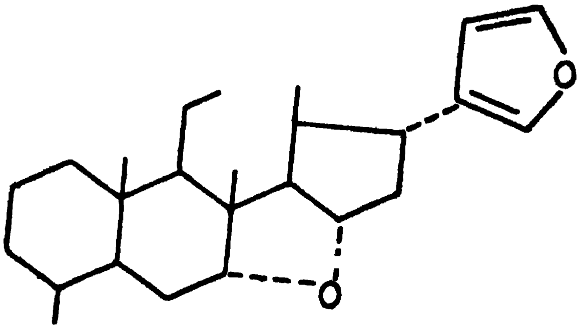
(45)



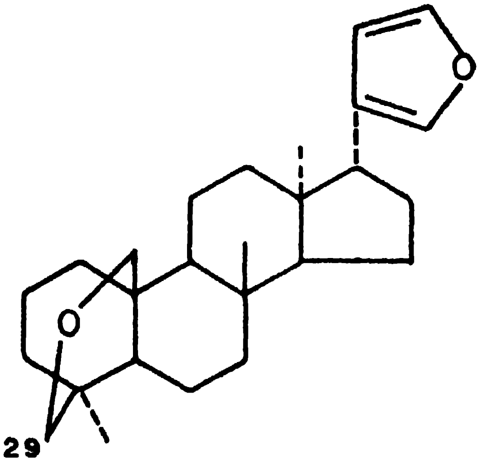
(12) 1α, 12α-(OH)$_2$; 3α-OAc ; 7α-tigloate ;
(46) 1α, 3α-(OAc)$_2$; 7α-tigloate ; 12α-OH
(51) 1α, 3α-(OAc)$_2$; 7α-OBz ; 12-oxo ;
(52) 1α, 3α-(OAc)$_2$; 7α-tigloate ; 12-oxo



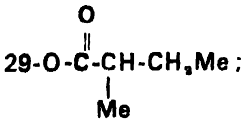
(42) 1α, 3α, 15β-(OAc)$_3$; 7α-OBz ; 12-COOMe ;
(43) 1α, 3α, 15β-(OAc)$_3$; 7α-tigloate ;
12-COOMe



(5) 1-Oxo ; 4α-OH ; 6α-OAc ; 12-COOMe ; Δ^{8}
(11) 1-Oxo ; 6α-OH ; 12-COOMe ; Δ^{8} ;
(35) 1-Oxo ; 4α, 6α-(OH)$_2$; 12-COOMe ; Δ^{8} ;
(39) 1-Oxo ; 6α-OAc ; 12-COOMe ; Δ^{8}

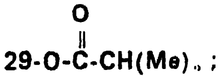


(29) 1α, 7α-(OH)$_2$; 2α, 3α-(OAc)$_2$; 11-oxo
14β, 15β-epoxy ;



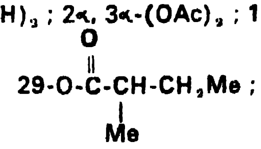
$29\text{-O-}\overset{\displaystyle \text{O}}{\overset{\|}{\text{C}}}\text{-}\underset{\displaystyle \text{Me}}{\underset{|}{\text{CH}}}\text{-CH}_2\text{Me}$;

(30) 1α, 7α-(OH)$_2$; 2α, 3α-(OAC)$_2$; 11-oxo
14β, 15β-epoxy ;



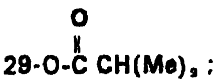
$29\text{-O-}\overset{\displaystyle \text{O}}{\overset{\|}{\text{C}}}\text{-CH(Me)}_2$;

(31) 1α, 7α-(OH)$_2$; 2α, 3α-(OAc)$_2$; 11,
15-dioxo ;



$29\text{-O-}\overset{\displaystyle \text{O}}{\overset{\|}{\text{C}}}\text{-}\underset{\displaystyle \text{Me}}{\underset{|}{\text{CH}}}\text{-CH}_2\text{Me}$;

(32) 1α, 7α-(OH)$_2$; 2α, 3α-(OAc)$_2$; 11,
15-dioxo ;



$29\text{-O-}\overset{\displaystyle \text{O}}{\overset{\|}{\text{C}}}\ \text{CH(Me)}_2$;

(56) 1α, 7α-(OH)$_2$; 3α, 12α, 29α-(OAc)$_3$;
11-oxo ; 14β, 15β-epoxy

29-positions in meliatoxin A_2(30) and meliatoxin B_2(32) have been detected.

(*f*) *Unsaturation :* The presence of double bond in limonoids is not very common except, of course, the furanoid double bonds. The Δ^1 and Δ^2 double bonds sometimes occur as part of the enone systems. However, Δ^7 and Δ^{14} double bonds are present in some of the compounds isolated from the two plant species.

Besides the tetranortriterpenoids, *viz.* melianol(26), melianone(27), meliantriol (28) which are normal C-30 triterpenes and are believed to be protolimonoids by their botanical origin, stereochemistry and tetrahydrofuran system at C-17 have also been isolated.

(*g*) *Biological activity* : Extensive studies on biological activity of preparations as well as pure compounds from neem *(A. indica* and *M. azedarach*) have been reported. Two reviews, one on the insect-feeding inhibition from the neem plant [33] and the other describing activity of neem products[34] have appeared. A review on twenty five compounds, some with anti-feedant activity against *Epilachna verivestis* have been reported[35]. Desacetylnimbin (nimbidin) has been reported to cause slowing the heart rate in frog followed by missing of beats. Spermicidal[36, 37] and diuretic[38,39] activities of nimbidin have been reported. The same compound at a dose of 200 mg/kg body-weight exhibited significant hypoglycaemic activity[40] by reducing the blood sugar level by 26% at the 5th hour of feeding. The compound has also been reported to possess anti-inflammatory activity[41]. Meliantriol, isolated from *M. azedarach*, exhibited locust anti-feedant[42] and azadirachtin isolated from both *A. indica* and *M. azedarach* showed phago-repellent, anti-feedant and systematic growth-disruptor[19, 43-46] properties. A polysaccharide isolated from *M. azedarach* containing glucose, arabinose and fructose on oral administration inhibited carsagenin induced inflammation in the foot pad of mice[47]. Two polysaccharides isolated from the same plant, when injected intraperitonilly at 5 mg/kg, showed anti-tumour activity against ascites sarcoma-180 in mice[48]. Evidence has been presented to show that meliatoxins A_1, A_2, B_1 and B_2 are responsible for the acute nervous systems and even death in pigs. Moreover, an attempt has been made to relate some clinical and histopathological findings to poisoning by these toxins[19]. □

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